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# DEVELOPMENT OF A COMMODITY STATISTICAL SAMPLING AND GRADING SYSTEM

Harry Blaine Robins

# NAVAL POSTGRADUATE SCHOOL
Monterey, California

# THESIS

## Development of a Commodity Statistical Sampling and Grading System

by

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June 1974

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basis on which the processing company determines the quality of the produce, its actual or predicted recoverable proportion, the amount of remuneration due the grower, and the overall accuracy of this process.

In seeking to establish a more consistent, accurate, and timely means of predicting actual production output, the use of statistical sampling and grading has become prevalent in the industry. This thesis attempts to evaluate a procedure for predictive analysis of one commodity, [illegible] in order to demonstrate the utility of this procedure for a wide range of productive processes.

# Development of a Commodity Statistical Sampling and Grading System

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In seeking to establish a more consistent, accurate, and timely means of predicting actual production output, the use of statistical sampling and grading has become prevalent in the industry. This thesis attempts to evaluate a procedure for predictive analysis of one commodity, in order to demonstrate the utility of this procedure for a wide range of productive processes.

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# I. INTRODUCTION

One of the newer and more rapidly expanding elements of the agricultural industry is the quick frozen food industry. The advent of quick frozen foodstuffs, combined with supportive technological advances resulting from World War II, has produced a major impact on the food processing and marketing industry and the eating habits of a major percentage of the nation's consumers.

The development of advanced large-scale refrigeration technology permitted the quick freezing and storage of perishable foodstuffs previously available only as fresh produce or canned commodities. Quick freezing requires facilities and a process that lowers temperatures rapidly and maintains low temperatures for an extended period of time.[1] Additionally, frozen foodstuffs require continuous refrigeration in all phases leading to final preparation for consumption.

Whereas the unique aspects of the industry have evoked major changes in the processing, transportation, storage and marketing segments of the industry, the area of financial arrangements between the grower and the processor of the produce have remained relatively unchanged.

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[1] Evers, C. F. and Tressler, D. K., The Freezing Preservation of Foods, 3d ed., p. 74-75, Avi, 1957 and Arnold, P. and White, P., Food: America's Biggest Business, p. 150, Holiday House, 1959.

It is the intent of this thesis to investigate the financial aspects of the grower-processor interface for one vegetable currently grown and processed in one of the major agricultural centers of California, the Salinas River Valley. Cauliflower has proven to be a source of potential discord between processing plant management and the independent grower. The primary element to be analyzed is the utilization of statistical sampling and grading techniques for determining financial payment to the growers. Although this analysis deals with raw vegetable produce, it is intended that it demonstrate the use of analytical methods of this type for assisting in the solution of a wide range of financial, production, and interface problems encountered in various industries and professions. Additionally, this study examines the background, composition, and environment of the California quick frozen food industry in order to determine the practical aspects of implementing a statistical sampling-grading system.

## A. BACKGROUND OF THE QUICK FROZEN FOOD INDUSTRY

The production of vegetable crops in the State of California has grown steadily since the beginning of the twentieth century. Prior to 1900, production was generally limited to fresh produce and canning vegetables due to limited markets, the lack of adequate preservation processes, and slow transportation systems. The forerunner of the quick frozen food industry, the canning industry did provide the initial beginnings of growth during the 1880's. As preservation and

refrigeration technology advanced, the 1890's saw the advent of the first fresh produce shipments from California farms to East Coast markets. By the end of World War I, California was established as the primary national production center of fresh market vegetables.

## B. GEOGRAPHIC GROWING REGIONS

### 1. General

The geography of the State of California has had a distinct effect on the distribution of agricultural production within the state. Mountains and untillable terrain have divided the state into several distinct areas suitable for agricultural production. These areas can be grouped into three major general regions: Southern California, the coastal valleys and terraces, and the interior valley of the Sacramento River and its tributaries. The state's quick frozen food processing industry is similarly distributed. The combined production of these regions accounts for approximately one-third of the nation's fresh vegetable market,[2] processing vegetables (canned and frozen), and fruit crops.[3]

### 2. Southern California Region

Southern California is divided from the northern three quarters of the state by the Transverse Ranges located

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[2] California Department of Agriculture, Sacramento, California's Principal Crop and Livestock Commodities, 1967.

[3] American Frozen Food Institute, Washington, D.C., Frozen Food Pack Statistics (1972), 1973.

just north of the Los Angeles Basin. Stretching from the Pacific coastline in Ventura County to the Mojave Desert in the east, the southern extremes of these ranges are known as the Santa Monica, San Gabriel, and San Bernadino Mountains. A coastal range running southeast from the Los Angeles Basin divides this region into the coastal areas of Orange and San Diego Counties, and the inland, semi-arid areas known as the Coachella and Imperial Valleys. Precipitation is restricted to the coastal areas, and irrigation is an operational necessity for agricultural efforts in the eastern extremities of the Los Angeles Basin, and the Imperial and Coachella Valleys.

Due to the widely scattered nature of the area, the majority of the existing frozen food processing industry is concentrated in the suburban areas of Los Angeles, coastal Orange County and the lowland areas of the Los Angeles Basin.

### 3. Coastal Region

This widely scattered area extends from Sonoma County on the north to Ventura County in the south. It is a relatively narrow area to the west of the various coastal ranges, and is characterized by fertile river valleys of varying size which drain to the Pacific Ocean, and a few coastal terraces. The majority of the valleys are surrounded on three sides by the coastal ranges, which in turn, generally follow the northwest-southeast orientation of the coast. Precipitation in these areas is seasonal, and generally heaviest in the immediate coastal areas. Irrigation and portable watering systems are

commonly utilized by growers, especially in the interior and southern portions of the valleys.

Three distinct concentrations of the quick frozen food industry sub-divide this region. Again geographic considerations predominate.

The northern-most area is the San Francisco Bay area. The fertile lowlands of the counties surrounding the Bay have long been a major production center of agricultural products. The southern extremity of the San Francisco Bay area, the wide and flat Santa Clara Valley, has been the center of the food processing industry in this locale for many years. However, the expansion of suburbs in this area has gradually reduced the acreage available for cultivation, thus curtailing expansion of the agricultural industry in this area.

The central coast area encompasses the coastal areas of San Mateo County and all of Santa Cruz, Monterey, and San Benito Counties. Included in this area is the highly productive Salinas-Watsonville agricultural complex, and the Salinas River Valley. Due in all probability to the geographic considerations and transportation networks involved, the major quick frozen food processors in this area are located in a belt extending through Santa Cruz, Watsonville, Castroville, and Salinas.

The southern coastal area encompasses the counties of San Luis Obispo, Santa Barbara, and Ventura. Processing in this area is limited and generally located in larger towns along the main transportation route, U.S. Highway 101. As in

the San Francisco Bay area, suburban expansion has decreased the amount of arable land available.

### 4. Interior Valley Region

Bordered by the coastal ranges on the west and the Sierra Nevada range on the east, this valley, known also as the San Joaquin Valley, is the largest conterminous agricultural production region in the state, stretching over four hundred miles in length and up to seventy-five miles in width. Precipitation is seasonal and locational, with the southern part of the valley being semi-arid. Water which runs off from the Sierra Nevada range is available for irrigation through an extensive agricultural canal system.

The food processing industry in this region is located in the central valley area reaching from Yuba City on the north to Fresno on the south, with the majority of the quick frozen vegetable processing portion of the industry concentrated in Stanislaus County within a small radius of the city of Modesto.

## C. DEVELOPMENT OF THE QUICK FROZEN FOOD INDUSTRY

### 1. General

The quick frozen vegetable processing industry was a development eminating from the slow freezing technology developed by the Pacific Northwest fruit industry prior to World War I.[4] As the levels of technology and investment

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[4] "Frozen Foods," Western Canner and Packer, v. 26, p. 7-9, September 1934.

increased in the post-depression years, the quick frozen vegetable industry rapidly developed in both size and scope. In 1937, the total vegetable pack in the United States showed a five hundred percent increase over the total for the previous year.[5] As investment capital became available during this year, quick frozen vegetable operations were commenced in the vegetable producing areas of the Mid-Atlantic States and California.

### 2. Vegetable Quick Freezing in California

The year 1937 saw the initial development of the California quick frozen food industry. As in any new venture, the failure rate of companies joining the industry was relatively high. The majority of the firms organized between 1937 and the beginning of World War II were situated in the San Francisco Bay area and the central Interior Valley region.

With the advent of World War II, the government became a major buyer of frozen foods. By 1943, approximately one-third of all frozen vegetables processed in the nation were directed toward the war effort.[6] However, as canned goods were more appropriate to wartime field conditions, the paper-packaged frozen foods began to play a vital role in feeding the home front population.[7] The majority of the firms joining

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[5] "Frozen Food Recorder," Western Canner and Packer, v. 29, p. 22, April 1938.

[6] Western Canner and Packer, v. 33, p. 50, November 1942.

[7] Hampe, E.C., Jr. and Wittenberg, M., The Lifeline of America: Development of the Food Industry, p. 154, McGraw-Hill, New York, 1964.

the industry during the war were located in the Interior Valley region or the San Francisco Bay area;[8] however, this period witnessed the initial efforts to establish the industry in the Watsonville-Salinas area of the Coastal Region.[9]

The period immediately following World War II was marked by rapid expansion of the frozen food industry in California as manpower and financial resources shifted from previous wartime commitments. As anticipation of high profits materialized, the number of firms entering the industry during the years 1946-1947 doubled the wartime entries. Much of this expansion was concentrated in the Interior Valley and the Los Angeles Basin. Pack volume in 1946 was nearly double the 1945 level.[10] Unfortunately, the nation's transportation and distribution systems did not match this level of expansion, and prolonged storage of unsold stocks of frozen vegetables was extremely high.[11] As a result of this overpack, numerous firms were forced into bankruptcy. Production declined from

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[8] Ketron, R.G., Locational and Historical Aspects of the Quick Frozen Vegetable Processing Industry of California, MA Thesis, University of Arizona, p. 40, 1968.

[9] Spiegl Foods , one of the most successful firms in the state, was established in Salinas in 1945.

[10] Ketron, p. 42.

[11] Ibid, p. 43.

95.2 million pounds of frozen vegetable packout in 1946 to 58.0 million pounds in 1947.[12] In 1948, industry management began to realize the wisdom of long range planning vice short term profit. The result established the industry on a viable footing that has sustained growth until the present.

The origins and backgrounds of the companies and men entering the quick frozen food industry were varied and indicate no particular, unique source.[13] The canning industry stands as a logical source and as a potential training ground for entries into the industry; however, three-fourths of all new firms were started by men with backgrounds other than canning. Representatives of these backgrounds are grower, food processor, food technology cold storage, shipper, investor, and engineer.

Information relative to the backgrounds of unsuccessful vegetable packing operations is limited, but tends to indicate that firms associated with frozen food processing, namely fruits, which expanded into the vegetable field, were most likely to terminate their vegetable processing operations.[14]

As the singular major production area of frozen vegetables in the nation, California has matched or surpassed

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[12] National Association of Frozen Food Packers, Washington, D.C., Frozen Food Pack Statistics, 1966, 1967.

[13] Ketron, p. 56.

[14] Ibid, p. 58. Analysis of this aspect of the industry is extremely limited, and the authors of this thesis are indebted to the analysis authored by Ketron.

the industry growth in recent years. Within the past decade, the total national pack of frozen vegetables has doubled (see Table I), and a significant portion of that expansion is the result of California based operations.

### 3. Development of the Quick Frozen Food Industry in the Central Coast/Salinas Valley Area

During the period from 1948 until the present, the trend towards industry expansion in the Interior Valley and the San Francisco Bay area ceased, and the Central and South Coast Regions assumed the major proportion of industry growth. Newcomers in these areas either challenged existing companies for a share in the market or were specialized in nature owing to the concentration of several small volume specialty vegetables grown in the area.

The Central Coast area and the Salinas Valley are representative of the California quick frozen vegetable industry. Numerous firms, many survivors of the initial days of the industry, compete within a relatively small geographic area. Farming is intensive, highly mechanized and generally dominated by large grower companies or corporations.[15] A wide range of vegetables are grown for frozen food processing in addition to produce grown for the fresh produce market.[16]

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[15] Numerous interviews and observations.

[16] During the course of this thesis, the following vegetables were packed in the Salinas Valley: Asparagus, Baby Lima Beans, Broccoli, Brussel Sprouts, Carrots, Cauliflower, Celery, Fordhook Lima Beans, and Spinach.

## TABLE I

## UNITED STATES FROZEN VEGETABLE PACK STATISTICS[17]

| Year | Total Packout (1) Excluding Potato Products | Total Packout (1) Including Potato Products |
|---|---|---|
| 1942 | NA (2) | 152,512 |
| 1943 | NA | 207,872 |
| 1944 | NA | 237,092 |
| 1945 | NA | 307,977 |
| 1946 | NA | 450,000 |
| 1947 | NA | 346,208 |
| 1948 | NA | 446,357 |
| 1949 | NA | 563,499 |
| 1950 | NA | 587,101 |
| 1951 | NA | 770,038 |
| 1952 | NA | 895,719 |
| 1953 | 1,032,579 | 1,103,270 |
| 1954 | 889,372 | 974,628 |
| 1955 | 1,010,805 | 1,139,695 |
| 1956 | 1,343,353 | 1,533,038 |
| 1957 | 1,146,705 | 1,366,565 |
| 1958 | 1,163,783 | 1,433,244 |
| 1959 | 1,255,553 | 1,626,601 |
| 1960 | 1,407,230 | 1,958,621 |
| 1961 | 1,536,879 | 2,116,041 |
| 1962 | 1,502,508 | 2,264,116 |
| 1963 | 1,460,839 | 2,322,376 |
| 1964 | 1,521,316 | 2,639,199 |
| 1965 | 1,714,579 (3) | 2,933,108 (3) |
| 1966 | 1,904,753 | 3,364,386 |
| 1967 | 2,016,816 | 3,417,621 |
| 1968 | 2,121,785 | 3,857,840 |
| 1969 | 1,866,823 | 3,915,731 |
| 1970 | 1,912,342 | 4,316,731 |
| 1971 | 2,009,243 | 4,574,361 |
| 1972 | 2,280,713 | 4,981,561 |
| 1973 | 2,467,325 | 5,158,398 |

Notes:

(1) Packout Totals are in thousands of pounds.
(2) Prior to 1953, potato products were included in the national totals as part of the miscellaneous vegetable count, and therefore can not be identified.
(3) From 1965 until the present, the packout of mixed vegetables was not included in national totals.

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[17] Compiled from Frozen Food Pack Statistics, Years 1954 to 1973, American Frozen Food Institute, Washington, D.C., 1955 to 1974.

Arable land is limited in amount, and is generally leased by the grower or grower company. The industry is highly specialized, and individual supportive firms provide a wide range of services within specific segments of the industry. Examples of these are produce transportation, refrigerated finished product stowage and transportation, harvesting and general farm labor.

The area is generally dependent on migrant labor for some phases of harvesting and growing operations. The labor problems that surfaced in the area during the late 1960's are still present, although not in previous proportions. Workers in the processing and transportation elements of the industry are unionized, but field workers generally are not unionized. Farm labor is normally provided by independent farm labor contractors. Being highly mechanized, the industry as a whole is subject to any adverse effects resulting from the non-availability of petroleum-based fuels, agricultural chemicals, and fertilizers.

A recent influx into the central-southern reaches of the Salinas Valley has been the speculative planting of vineyards to support anticipated growth in the California wine industry. To date, these vineyards have been concentrated in lands generally thought as unproductive for vegetable growing purposes, but should this trend of vineyard development continue, the use of land for vineyards could compete with the more favorable farming lands presently used for other crops.

The frozen food processing firms operating in this area have generally concentrated their operations in the speciality vegetable market.[18] Consequently, the vegetables grown in the Salinas Valley are processed for sale under company labels, or under contract with national food wholesale and retailing firms. Additionally, vegetables are processed for sale as ingredients for the products of other food processing firms. These products include frozen dinners, canned soups and canned stews.

Overall, the industry within this area has enjoyed steady growth since World War II; this growth has been sustained by a steady supply of high quality raw produce. Competition, combined with the geographic limitations of the area and the resultant limited number of growers, has dictated that processing firm management establish and maintain policies that promote and maintain positive and favorable relations with growers.

## D. GROWER-PROCESSOR RELATIONSHIPS

### 1. General

The success of a quick frozen food firm's operations is directly dependent on the mutual satisfaction derived from the grower-processor relationship. Many factors contribute to this relationship, loyalty being a dominant one. Growers

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[18] Speciality vegetables include asparagus, broccoli, brussel sprouts, carrots, cauliflower, fordhook lima beans, baby lima beans, and spinach. These vegetables are contrasted to staple vegetables such as peas, corn, potatoes, and beans, grown primarily in other locations in the state.

tend to be loyal to processing companies with whom they have dealt successfully during the previous seasons. Likewise, processing companies have a strong degree of loyalty towards reputable vegetable growers who have a history of contracting with their company. Mutual respect and traditional practices, some dating to the pre-frozen vegetable era, are evident in this industry.

The basic ingredient of this relationship is the financial system. The amount of payment rendered by the processor for raw produce delivered by the grower and the means by which the grower's remuneration for this produce is determined stand out as the primary factors affecting the grower's satisfaction with a particular processing firm. Dissatisfaction with a particular processor's means of determining payment for produce, as well as the actual prices paid, could and does result in a grower's contracting with another packing firm for future growing seasons, or reluctance to plant specific vegetables. In the Salinas Valley, this latter action has caused drastic reductions in the plantings of certain vegetables.[19] In turn, failure to meet the demand for these vegetables from other sources causes virtual disappearance of the frozen produce from retail display cases, or at least, a marked increase in price.[20]

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[19] Interviews with various growers and Mr. Robert Mills, Manager , Salinas Valley Independent Growers Association.

[20] Asparagus, green peppers, and several vegetables that amount to a smaller percentage of the total vegetable pack are affected. Also, contributing factors include the labor intensive nature of some of these vegetables, which must be considered a financial element of the problem.

### 2. Interface Between the Grower and the Processor

The interface between the grower and the processing company is accomplished by the fieldman. Employed by the processor, this ubiquitous individual becomes the primary point of contact for the grower on a wide range of matters. Although duties with various firms will vary, a typical fieldman could be responsible for the initial contracting efforts, monitoring the actual production of crops, monitoring or supervising harvest operations, and supervising and coordinating the shipment of the raw produce from the field to the processing plant. His detailed knowledge of growing conditions, individual land parcels, and the talents and capabilities of specific growers, enable him to negotiate on the company's behalf for specific vegetable crops to be grown on specified acreage. His efforts result in the initial business agreement between grower and processor, which is later formalized with a detailed, written contract. However, his supervision during the growing and harvesting periods is the primary means through which the processor ensures that the grower complies with the terms of the contract. The fieldman's responsibility for a particular crop usually ends when he has ensured timely delivery of the harvested produce in a steady flow to the processing plant.

Thus, the fieldman is a vital element in determining the level of confidence that exists between the processor and the grower. His accountability extends from the contracting stage of relations to the completion of harvesting, and his importance should not be underestimated.

### 3. The Nature of Contracts Between Grower and Processor

The business agreement is based on a contract between the processor and grower. The grower agrees to plant a specific number of acres of a certain vegetable to be harvested and delivered to the processor within a specified time frame. The price is negotiated, and payment is determined in the frozen vegetable industry by one of two bases, either actual packout weight of final frozen product by pounds, or predicted packable weight based on a statistical sampling and grading plan and procedure determined and administered by the processor. Additionally, a provision may be made for a minimum payment per harvested acre, thus affording the grower a measure of protection for his financial investment. Harvesting responsibilities and payment schedule provisions also may be delineated, in addition to various other minor details.

Price is not normally a major negotiation subject because it is either firmly established by competition within a general range, and thus a "take-it-or-leave-it" proposition, or negotiable only within a narrow range. On the other hand, the basis for payment is often the major point of contention and the source of potential difficulties in the grower-processor relationship. The two principal systems are based on packout weight or statistical sampling, or in some instance, a combination of one of these primary systems with third party grading.

### a. Packout Basis

Under the final packout system, the grower's raw produce is delivered to the processing plant, weighed, accounted for, and processed by a production run identified as a specific grower's field. The production count is tallied daily, and at the completion of all runs from the specific field, a final tally is made, and the grower is paid a specified price per pound of final output. Normally, payment would be based upon final harvest count, often a matter of several weeks from the initial delivery from that specific acreage or field. A more frequent, partial payment, however, can be specified in the contract.

This total packout payment system is not frequently used because of its general unpopularity with growers. The final production count and the grower's payment can be adversely affected by delays in introducing the raw produce into processing, production difficulties, and quality control procedures. Produce lost in processing is at the grower's expense, and no viable incentive exists for plant production personnel to ensure that maximum recovery of packable produce is obtained. Although physical custody and responsibility of the raw produce shifts to the processor upon harvesting or upon arrival at the processing plant, financial responsibility is borne by the grower until final production count. This delay in determining the amount of final payment and the fact that it is vague until final output count can be burdensome to the grower in terms of his financial planning for completing

the present season and for future plantings. Herein lie the sources of dissatisfaction responsible for the final packout system's decline as a basis for payment within the industry.

b. Statistical Sampling and Grading Basis

A viable alternative exists in the statistical sampling and grading method. Raw produce is sampled upon arrival at the processing plant, graded by plant graders and the percentage of recoverable (packable) produce determined. This percentage, less "dockage" for specific defects, is applied to the total raw produce input and a predicted packout is determined. The grower is paid on this predicted figure, usually on an interval specified in the contract.

This system has benefits and detracting aspects for both the grower and processor. Considering the predicted packout as valid, management and production personnel can use this figure as a quantity control device to assess the efficiency of plant operations. Comparison of predicted recovery to actual recovery is possible for this purpose. The processor in effect accepts financial custody for the produce prior to processing, and the incentive for maximum recovery thus exists from a profit and fiscal standpoint.

The grower is no longer at the mercy of the efficiency of the production system for his final payment, and is not inclined to monitor the actual production process to ascertain his fair treatment by the processor, unless he suspects disparity between predicted and actual packout. The grower is able to observe the actual grading operations and

verify the content of the grading sheets. Financial responsibility in effect shifts with the physical responsibility upon arrival and sampling of raw produce at the processing plant.

However, the grower does not entirely view this system with complete favor and trust, and any attempt to regard it as a panacea would be a folly. While growers' attitudes vary widely, and often with respect to their treatment by specific processors, several negative aspects are identifiable.

From the growers' viewpoint, the fact that grading of the samples is conducted by processor personnel, often under the supervision of production management personnel, indicates that the results of the sample are subject to manipulation and modification to meet the desired outcome of the processing company. Implicit in this grower attitude is the possibility that sample results could be altered to mask inefficiencies in actual processing production, or to effect a lower total payment than that which would be warranted based on actual packout or the original grading results.

The flexibility of grading standards likewise is a potential point of contention. Growers tend to feel that packers will modify the grading standards in response to market conditions for specific vegetables. Periods of low demand for a vegetable would result in more stringent standards being applied. However, it is conceivable that

the reverse could occur, resulting in greater benefit and remuneration to the grower. Evidence indicates that processors would tend to employ this tactic in order to prevent discouragement of growers during poorer growing periods, or to meet some artificial recovery percentage that growers feel should be obtained from their raw produce.

Although either of these two potential drawbacks to a graded sample based payment system could operate to benefit either the grower or processor, depending upon the situation and circumstances involved, the fact that the capacity to apply these means is controlled by the processor is the major consideration. Generally, growers feel that the processor controls the situation, has available various means that could be used to reduce grower payment, and may employ these means at his discretion. If a grower feels that a particular packer has employed some means to decrease the payment involved, his only recourse is to refuse to contract with that processor in forthcoming seasons.

### c. Third Party Grading

In an attempt to correct the shortcomings of the statistical sampling and grading system as described above, efforts have been directed towards the establishment of third party grading systems. Although it is not yet found in widespread use in the quick frozen food industry, the possibility of its development and the implications and advantages involved warrant its mention here.

The California tomato growing industry has implemented and is successfully using a system of third party inspection.[21] This system was developed jointly by processing firms, the California Department of Agriculture, and the growers, represented by the California Tomato Growers Association. Under this system, a licensed third party inspection station, normally located at the processing plant, samples and grades the raw produce. The expense of grading is borne jointly by the grower and processor. Standards, established by mutual agreement of all three parties and written into law, are employed, and an official State of California Department of Food and Agriculture Inspection Certificate is issued for all loads of raw produce meeting the established standards. Defects are listed in percentages. The inspection station operators are supervised by officials of the California Department of Food and Agriculture. This system has been in successful operation for over twenty years, and is considered a major step forward in improving grower-processor relationships.

### 4. The Influence of Growers' Associations

A recent and expanding concept in the area of grower-processor relations has been the development of associations composed of growers. Headed by competent individuals experienced in both business and agriculture, these

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[21] The California Tomato Grower, "1973 Tomato Inspection Procedures," v. 16, n. 6, June 1973.

organizations represent growers collectively in such matters as pricing, contract terms, standards, and various other matters in dealings with the processing firms. Consequently, the associations provide a strong measure of stability, and have been active in establishing common standards and procedures within the industry. Although a relatively recent movement within the vegetable growing industry in the Salinas Valley, it is evident that organizations such as the Salinas Valley Independent Growers' Association will play a more important part in grower-processor dealings in the future.

## E. RELATIONSHIP WITH A REPRESENTATIVE PROCESSING COMPANY

### 1. Reason for Relationship

In order to develop the data for this thesis, it was necessary and desirable to establish a working relationship with a specific quick frozen vegetable processor that would be representative of the industry. Through this relationship, it would be possible to correlate sample data obtained in a proposed sampling-grading evolution with actual input-output data. The desired relationship was developed with Spiegl Foods, Incorporated, one of the original California vegetable processing firms.

### 2. History of Spiegl Foods, Incorporated

Founded in 1945 by Mel K. Spiegl in Salinas as Spiegl Farms, the company failed and was reorganized in 1947 following the industry overpack and retrenchment period. Following reorganization, the company prospered and concentrated on packing several speciality vegetables common to the Salinas

area. During the period from 1947 until 1960, Spiegl became California's leading processor of frozen carrots. In the early 1960's, an investment banking firm, Wertheim and Company, acquired the controlling interests in the corporation. In January 1967, Spiegl Foods, as the firm was now known, acquired Knudsen Frozen Foods, a Santa Maria-based firm (Southern Coast area). This acquisition was accomplished in order to provide increased production capacity. A new management staff took over operations in early 1968, and initiated a period of sustained growth for the firm (see Table II). In March 1968, Alameda Frozen Foods, Inc., a speciality processing firm located in Salinas was acquired, and in January 1972, the Liquid Ice Company, also of Salinas, was purchased. This firm owned the facilities and equipment leased by Spiegl for its Salinas operations. This acquisition gave Spiegl ownership of all property and refrigeration equipment at its Salinas locations. In April 1973, a cold storage facility, Reliable Cold Storage Company, located adjacent to the Salinas plant, was acquired and integrated into the Salinas operation. Finally, the Brendlin-Rice Company, located in Santa Maria, was acquired in late 1973 to provide greater production capacity.

The new management of Spiegl Foods, Inc. established and pursued balanced growth objectives following the change in ownership. Summarized, these objectives were:

## TABLE II

## FINANCIAL RESULTS OF CORPORATION OPERATIONS[22]
## SPIEGL FOODS INC. 1963-1973

| Year | Sales (1) | Net Earnings (1) |
|---|---|---|
| 1963 | 5,562 | 157 |
| 1964 | 5,499 | 138 |
| 1965 | 5,727 | 215 |
| 1966 | 6,266 | 267 |
| 1967 | 8,124 | 470 |
| 1968 | 8,052 | 80 |
| 1969 | 10,751 | 106 |
| 1970 | 10,696 | 204 |
| 1971 | 13,492 | 647 |
| 1972 | 17,512 | 852 |
| 1973 | 20,500 | 635 |

Note:

(1) Sales and Net Earnings listed in thousands of dollars.

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[22] Spiegl Foods, Inc. Annual Report, 30 June 1975, and Spiegl Foods, Inc. Letter, Subject: Recent Sales and Earnings of Spiegl Foods, Inc., 11 April 1974.

1. Continuing to increase the volume of business on present products with present customers and with new customers.
2. Developing several new products which will be sold to its present customer list as well as to customers acquired in the future.
3. Acquiring companies similar to Spiegl, with products which Spiegl does not presently process and which will will be marketed to the present customer list.[23]

Spiegl's sales distribution encompasses three major and two minor areas. Approximately thirty percent of sales are allocated to the consumer size packages retailed in supermarkets. Another thirty percent is institutional pack of vegetables to be utilized in large scale feeding facilities, such as restaurants, schools, etc. The third major product area is the ingredient pack which is sold to food processors for use in soups, stews, frozen dinners, etc. The remaining ten percent is divided between sales to governmental institutions and co-packing for major frozen food companies of products for which Spiegl possesses greater proficiency.[24]

Over the years, Spiegl Foods' strength could be attributed to a well trained production staff backed by an aggressive and competent sales force, and a well planned

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[23] "Growth in Vegetables," Over-The-Counter Review, Nov. 1972.

[24] Interviews with Mr. Paul Rembert, Vice President for Operations, Spiegl Foods, Inc.

program of raw produce acquisition. Although several key management positions were changed following assumption of control by Wertheim and Company, it is evident that the new owners recognized the value of competent management characteristic of this firm, and have attempted to build on this foundation. The company remains very conscientious in its dealings with its contracted growers, and is anxious to foster and develop positive relationships with its sources of raw produce. Spiegl Foods, Inc., presently operates two plants in Salinas and two plants located in Santa Maria.

# II. PROBLEM AREA

As indicated in the preceding chapter, two basic means exist whereby the processing company determines the amount paid to the grower for the raw produce delivered. These systems are the actual packout physical count procedure, and the statistical sampling and grading procedure. Both methods were employed by Spiegl Foods, Inc., for specific vegetables processed during 1973.

The use of the total packout count system has been gradually phased out in Spiegl Foods' operations and replaced by the statistical sampling and grading method. This method is presently employed for nearly all vegetables packed by Spiegl Foods with success and general acceptance by the growers involved. Normally, United States Department of Agriculture (USDA) standards, or a modification thereof, are utilized as grading criteria by trained and experienced grading personnel. The single exception to this statement has been the vegetable cauliflower, for which growers have been paid on a total packout count system for processing seasons prior to and including the 1973 fall harvest.

## A. CULTIVATION AND HARVESTING OF CAULIFLOWER

Frozen cauliflower is prepared from the fresh flower heads of the cauliflower plant (Brassica Oleraca Botrytis) by a

process that includes trimming, washing, and blanching prior to actual freezing.[25]

The finished frozen cauliflower product is graded according to USDA quality standards, and assigned grade of "U.S. Grade A" or "U.S. FANCY","U.S. Grade B" or "U.S. Extra Standard", or "Substandard" as appropriate.[26]

The amount of cauliflower processed and packed by the California food industry is significant. (See Table III.) Since 1959, California frozen vegetable processing firms have produced over fifty percent of the nation's total output of frozen packed cauliflower. This percentage has increased steadily in the past twenty years, and now accounts for approximately twenty percent of Spiegl Foods' total packout.

As the available acreage has decreased in the South Coast and San Francisco Bay areas, the bulk of California's total production has shifted to the Central Coast area where approximately fifty percent of the state's cauliflower is now produced. Monterey County, which includes the majority of the Salinas River Valley, alone accounted for forty-three percent of the state's acreage committed to cauliflower production in 1971 and 1972.[27]

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[25] United States Standards for Grades of Frozen Cauliflower, United States Department of Agriculture, 12 Nov. 1951. (See Appendix H)

[26] Ibid.

[27] California Crop and Livestock Service, California Vegetable Crops, 1964-1972, County Acreage, 1971-1972, p. 26, August 1973.

## TABLE III

## CALIFORNIA AND NATIONAL CAULIFLOWER PACK STATISTICS[28]
## 1945-1973

| Year | California Cauliflower Total Packout (1) | National Cauliflower Total Packout | Calif. Cauli. P/O as % of Nat. Cauli P/O | National Cauli. P/O as % of National Total P/O |
|---|---|---|---|---|
| 1945 | 2,900 (4) | 7,391 (1) | 39% | 2.5% (2) |
| 1946 | 8,400 | 13,237 | 63% | 3.0% (2) |
| 1947 | 3,000 | 5,353 | 56% | 1.7% (2) |
| 1948 | 9,000 | 13,963 | 64% | 3.3% (2) |
| 1949 | 13,000 | 21,655 | 60% | 3.8% (2) |
| 1950 | 4,400 | 12,339 | 36% | 2.2% (2) |
| 1951 | 10,000 | 22,428 | 45% | 3.0% (2) |
| 1952 | 19,100 | 33,166 | 58% | 3.7% (2) |
| 1953 | 17,400 | 35,710 | 49% | 3.5% (3) |
| 1954 | 7,900 | 17,088 | 46% | 1.9% |
| 1955 | 20,100 | 40,086 | 50% | 4.0% |
| 1956 | 19,600 | 47,159 | 42% | 3.5% |
| 1957 | 9,300 | 22,690 | 41% | 2.0% |
| 1958 | 16,300 | 33,251 | 49% | 2.9% |
| 1959 | 23,400 | 33,566 | 70% | 2.7% |
| 1960 | 29,400 | 48,742 | 60% | 3.5% |
| 1961 | 27,800 | 41,117 | 68% | 2.7% |
| 1962 | 25,100 | 37,805 | 66% | 2.5% |
| 1963 | 28,200 | 40,677 | 69% | 2.8% |
| 1964 | 31,100 | 43,596 | 71% | 2.9% |
| 1965 | 28,284 | 46,211 | 61% | 2.7% |
| 1966 | 39,465 | 53,985 | 73% | 2.8% |
| 1967 | 35,854 | 50,971 | 70% | 2.5% |
| 1968 | 52,146 | 67,566 | 77% | 3.2% |
| 1969 | 55,554 | 69,744 | 80% | 3.7% |
| 1970 | 49,348 | 59,782 | 83% | 3.1% |
| 1971 | 54,588 | 67,659 | 81% | 3.4% |
| 1972 | 79,046 | 94,070 | 84% | 4.1% |
| 1973 | 77,268 | 96,098 | 80% | 3.9% |

Notes:

(1) Packout totals are listed in 1000 pounds.

(2) Percentage approximate due to total national packout figures including but not identifying potato products.

(3) From 1953 to 1973, percentage computed on total vegetable packout excluding potato products from the total.

(4) California Cauliflower packout figures from 1945 to 1964 are approximate due to the California packout being included in a total western area packout.

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[28] Compiled from Frozen Food Pack Statistics (Years 1954 to 1973), American Frozen Food Institute and Ketron.

The nature of cauliflower presents unique challenges and problems for both grower and processor. Like most vegetables planted in Spiegl Foods' area of operations, the primary cauliflower crop is planted in the spring for the fall harvest period, between mid-October and the end of December. A secondary crop is planted in the fall and harvested in the late spring. A relatively narrow planting season is thus covered, due to the cyclical use of land. Consequently, soil conditions are critical during this period. An over-abundance of winter or spring rainfall can seriously delay or hamper planting, thus causing delays in harvesting and creating a severe strain on production facilities during the following autumn.

Cauliflower, not being an especially hardy vegetable, generally requires planting in the better soil areas. During its period of growth, cauliflower requires a normal amount of cultivation and general attention by the grower. Moisture and the amount of sunlight are critical during growth. Approximately four to six weeks prior to harvest, the long exterior leaves of the plant must be manually secured in a manner that completely covers the head, or flower portion of the vegetable. This is done to prevent early maturing of the head, and discoloration, or yellowing, due to excessive exposure to sunlight.

During this final period of growth, moisture conditions are critical, as an accumulation of water inside the tent formed by the secured leaves can cause rot or mold on the flower portion of the vegetable.

The harvesting operation must be timed to prevent over-maturing of the individual flowers or pedicels. Unlike other vegetables, cauliflower harvesting remains a manual operation. Agricultural technology has not yet produced equipment that can pass through a field of this vegetable, identify plants that are mature and of harvest quality, and then effect the cutting and harvest. As each plant must be visually checked for its condition and state of maturity, with the head still covered by the plant's long leaves, it is necessary for the harvesting crew to walk along the rows of the vegetable, inspect each plant, and cut it from its root structure and base with long harvesting knives. Two methods exist for loading the harvested vegetable for transport. The preferred conveyor method involves a mechanical self-powered conveyor moving perpendicular to the rows with the harvesters walking behind the machine. The vegetables are inspected, cut, and placed on the conveyor, which in turn loads the heads into a trailer pushed or pulled at the end of the conveyor. Approximately twenty rows can be harvested simultaneously in this manner. The secondary method involves a single trailer (or two trailers towed in tandum) being towed through the field with harvesters working on either side and behind the trailer. The vegetables are again harvested manually, but in this instance, the cut heads are thrown into the trailer. This method is slower, less effective, but used if field conditions (water, mud, etc.) do not permit the use of the conveyor. During harvesting, the vegetable is subject to

damage and bruising particularly if inexperienced harvesting personnel are used or the cut heads are thrown too roughly into the trailer. The conveyor method of harvesting is more efficient due to its higher operational speed and the ease of supervision. However, the capital investment in a conveyor system is large. These units are normally owned by the processing firms or independent harvesting concerns.

It becomes obvious upon observation that the level of experience and supervision of the harvesting crew has a direct bearing on the quality of the harvest. Identification of the mature vegetables, proper cutting, and care in loading are essential factors. A field may be harvested from three to six times because of uneven ripening.

The problems do not end with harvesting. Transport to the processing plant must be timely. Delays in processing the raw produce after arrival at the plant subjects the cauliflower to deterioration or discoloration caused by moisture, heat, or sunlight, or a combination of all three elements. Discoloration appears to be serious if processing is not done within twenty-four hours of cutting. However, this is a function of exposure time to both sunlight and heat.

## B. SITUATION OF SPIEGL FOODS, INC.

Being a progressive company under the management of experienced and highly motivated executives, Spiegl Foods, Inc., is anxious to maintain the confidence of its growers in its endeavors to provide accurate and timely payment for raw produce received for processing. Faced with increasing grower

disenchantment and resistance to the total packout count payment basis utilized for its cauliflower production, the company has sought to develop an accurate statistical sampling and grading system.

Previous attempts by Spiegl Foods and other companies to develop a sampling grading system of acceptable accuracy have been hampered, or prevented, by the characteristics of the vegetable. Especially troublesome is the fact that in excess of fifty percent of the total weight of an average harvested load arriving at the processing plant is composed of leaves, stalks, and other unusable parts, known collectively in the industry as trim loss. Further, some discoloration in the raw produce can be removed during the blanching portion of the processing, and determining whether this is possible is extremely difficult to all but the most experienced graders.

# III. PROPOSED STATISTICAL GRADING SYSTEM FOR CAULIFLOWER

The essentials of a statistical grading system for cauliflower were proposed by the processing department of Spiegl Foods' Salinas plant for implementation during the 1973 fall harvesting season. Although not an ideal growing season for cauliflower, the assumption was made and concurred in that valuable experience would be gained by implementing and testing the system during a non-typical season in which a wider range of quality and defects was possible. All inputs of three different growers, Interharvest, Inc., Whitney Farms, and Bengard Farms, were to be sampled and graded according to plan with inputs identified by grower and specific field or land parcel. Standard company output records of total packout count by grower and date would be maintained.

## A. PROPOSED SAMPLING AND GRADING PLAN

Under the proposed plan, samples were to be drawn from each raw produce load arriving at the plant. A load normally would consist of two trailers. A sample would consist of fifteen heads of cauliflower drawn at random from the load, ensuring that eight heads were drawn from one trailer and seven heads were drawn from the other trailer. No distinction or pattern would be associated with which number was drawn from which trailer. It was intended that the samples be drawn just prior to unloading for processing, or as soon after arrival as possible. At this point in time, the samples would

become the custody of the raw produce graders, and were to be transported to the company's grading area adjacent to the initial production line.

The fifteen head sample would be weighed by the graders to determine total sample weight. This and all subsequent weights determined in the grading evolution would be obtained with accuracy to .25 pounds. The sample heads would be reduced manually by the graders in the same manner employed on the production line, and the vegetable separated and categorized as follows:

1. Grade "A. (The primary packable vegetable)
2. Grade "B" Color. (With discoloration as a defect)
3. Grade "B" Maturity. (With mature portions as defects)
4. Rot and damage.
5. Trim Loss. (Leaves, stalks, shoots, dirt, etc.)

The individual categories would be totalled and recorded, and a double-check of these figures performed to ensure that the sum of the individual sample categories equalled the total sample weight.

The basic standards to be employed by the company graders to classify the raw produce were United States Department of Agriculture originated United States Standards for Cauliflower for Processing. (See Appendix H.)

The inspection would be conducted by two regular Spiegl Foods' personnel experienced in raw produce grading procedures. Both were considered highly competent and trusted employees, familiar with the grading of a wide range of vegetables.

Although neither of these employees were experienced in the grading of raw cauliflower and the standards to be employed, they were to be thoroughly briefed in all matters relating to this new duty. The assignment of these personnel to the processing department would remain in effect, and supervision would be provided by the plant superintendent. Any instructions relative to sampling or interpretation of applied standards beyond the capacity of the graders would be obtained from the plant superintendent.

## B. HYPOTHESIS

It was hypothesized that the sampling and grading system outlined above could be further developed, perfected and employed to determine the proportion of the primary packable raw produce (usually grade "A") and packouts of other qualities contained in a given input with sufficient reliability and accuracy to permit prediction of total output of each product that could be derived from said input. The degree of confidence associated with this prediction would be sufficiently high to permit its utilization as a means for payment for the raw produce received. Thus, payment could be made sooner after the delivery of the raw produce. Additionally, development of this system would enable the company to eliminate the total packout count system of payment for cauliflower, thus, creating conditions conducive to reinforcing grower confidence. Further, it was hypothesized that the predicted output would possess valid utility in evaluating quality control and overall plant operating efficiency.

On the broader scale, proof of the validity of this hypothesis would demonstrate yet another use of a versatile and functional management tool, statistical sampling and grading, that could be functionally adapted and reliably employed in numerous diverse applications, both in military and industrial environments.

## IV. COLLECTION OF DATA AND THEIR ANALYSIS

Sample and production data for the fall 1973 cauliflower processing season was gathered by Spiegl Foods, Inc. Samples were taken from trailer loads of cauliflower (a load consisted of two trailers hauled in tandum) when the trailers arrived at the processing plant. Sample and production data was identified by trailer and receiving report numbers, date, grower and field number.

### A. SAMPLING PROCEDURES

A sample consisted of fifteen heads of cauliflower selected at random from the two trailers. Seven heads of cauliflower would be randomly selected from one trailer and eight heads would be randomly selected from the other.

The majority of cauliflower introduced into production arrived at the processing plant in trailers, however bins and baskets were also used to a small extent to transport cauliflower from the field to the processing plant. If cauliflower was received in bins or baskets, these bins and baskets were carried on a trailer. Eight bins or four baskets made up one trailer load of cauliflower. The bins and baskets were also randomly sampled, so that a total of fifteen heads would also be sampled from a trailer load of bins and baskets. Actual sample data (see Appendix B and Appendix D), to the nearest quarter pound, for each day consisted of:

Total Pounds Sampled (SAMWT)

Sample Weight of Grade "A" in Pounds (SAMA)

Sample Weight of Grade "B" Color in Pounds (SAMBC)

Sample Weight of Grade "B" Maturity in Pounds (SAMBM)

Sample Weight of Trim Loss in Pounds (SAMT)

Sample Weight of Damage and Rot in Pounds (SAMD)

The mean weight of a trailer load (two trailers) was 6,391 pounds with a standard deviation of 709 pounds. The mean weight of a bin of cauliflower was 895 pounds with a standard deviation of 146 pounds. The mean weight of a basket of cauliflower was 1,254 pounds with a standard deviation of 132 pounds.

## B. PRODUCTION PROCEDURES

Cauliflower was introduced into production in the order in which it was received at the processing plant, with each grower's product separated from others by a few minutes delay. Normally only one grower's product was harvested on a given day so there was no major problem involved in determining which grower's cauliflower was being processed at any specific time.

Actual production data (see Appendix A and Appendix C) consisted of:

Number of Trailer Loads (Trailers, Bins, Baskets) of Cauliflower Received

Number of Trailers Introduced into Production

Total Raw Cauliflower Input into Production (TIP)

Grade "A" Packout (POA)

Grade "B" Packout (POB)

Pieces Packout (POP)

It is necessary to understand that cauliflower packed as grade "A" may have a volume of up to 10% of a lower grade.

## C. DATA COMPILATION

For each specific load of cauliflower introduced into production, specific production data was not identified with that specific load. Due to this fact, sample and production data was grouped to correspond with available actual production data by date, grower, and the grower's field number. If the number of trailers received was not the number of trailers introduced into production on a given day certain assumptions were made: (A1) It was assumed that trailers not processed the same day as received were processed as soon as possible on the following day. (A2) It was further assumed that samples of cauliflower were graded in the order trailers were received at the processing plant. Therefore, the last samples taken and grading data recorded would be for trailer loads carried forward to the following day. If however, a grower's cauliflower was received, sampled, graded and partially processed on a given day, with the remainder being processed the following day, and no cauliflower was received the following day, the sample and production data would be grouped into one day.

Available sample and production data grouped as described above were referred to as cases. A total of fifty-eight cases

were identified from the 1973 fall harvesting and processing season. Two cases lacked complete sample data and were ultimately discarded.

## D. DATA ANALYSIS

Analysis was performed in order to be able to predict the packout of grade "A" (POA), the packout of grade "B" and the packout of pieces (POP) based on known data, total input in pounds (TIP), sample weight (SAMWT), sample grade "A" (SAMA), sample grade "B" color (SAMBC), sample grade "B" maturity (SAMBM), sample trim loss (SAMT), and sample damage and rot (SAMD). See Appendix A through Appendix D for data actually used in the analysis.

Upon analysis of the ratios POA/TIP and POB/TIP, it was determined that there were two distinct groups of data. The ratio POA/TIP showed 48 cases which had a mean packout of grade "A" of 20.9%, a mode of 21% and a range from 12% to 32%. The remaining 8 cases had a mean packout of grade "A" of 1.6%, a mode of 1.5% and a range from 0% to 4%. The ratio POB/TIP showed the same 48 cases had a mean of grade "B" packout of 0.8%, a mode of 0% and a range from 0% to 8%. The 8 cases had a mean packout of grade "B" of 22.8%, a mode of 21.5% and a range from 20% to 29%. Due to this fact the 48 cases were identified as grade "A" production line run, A-RUN, in which the packout of grade "A" was greater than 12% of the total cauliflower input weight. The remaining 8 cases were identified as grade "B" production line run, B-RUN, in

which the packout of grade "B" was 20% or greater of the total raw cauliflower input weight.

When analyzing the ratio of pieces to total input weight (POP/TIP), there was no distinct separation between A-RUN and B-RUN. In the 48 cases previously identified as A-RUN the data regarding the ratio POP/TIP had a mean packout of pieces for A-RUN of 0.9%, a mode of 0% and a range from 0% to 4%. In the 8 cases identified as B-RUN analysis of the ratio POP/TIP showed a mean packout of pieces for B-RUN of 1.7%, a mode of 0% and a range from 0% to 7%. Due to the above fact A-RUN and B-RUN cases were combined so that when predicting packout of pieces (POP) it is not necessary to determine whether a grade "A" or grade "B" production line was being run.

A multiple regression analysis which attempts to predict the values of unknown (dependent) variables (i.e., POA, POB, and POP) from known (independent) variables (i.e., TIP, SAMWT, SAMA, SAMBC, SAMBM, SAMT and SAMD) was utilized. Results of this analysis follow:

1. Packout of Grade "A" with a Grade "A" production line run (A-RUN)

   $$POA = 2517 + 0.23(TIP) - 83(SAMBC) - 157(SAMD)$$

2. Packout of Grade "A" with a Grade "B" production line run (B-RUN)

   $$POA = -219 + 105(SAMBC) - 33(SAMA)$$

3. Packout of Grade "B" with a Grade "A" production line run (A-RUN)

   $$POB = -704 + 42(SAMBC)$$

4. Packout of Grade "B" with a Grade "B" production line run (B-RUN)

   $POB = -1451 + 83(SAMWT) - 50(SAMD)$

5. Packout of Pieces

   $POP = 214 + 73(SAMD) - 22(SAMA) + 4(SAMWT)$

See Appendix E for a detailed breakdown of the multiple regression analysis.

# V. CONCLUSIONS

## A. SOLUTION

### 1. General

Based on the data obtained from the 1973 fall harvest season, and the analysis of data described in the preceding chapter, general regression equations were developed to predict the three specific outputs of frozen cauliflower production. Although the data involved in obtaining these equations was isolated to one specific time frame and harvest period, it is concluded that these equations are general in nature and applicable to general industry usage. Two reasons are offered to support this conclusion. Firstly, the variables identified and included in the equations are general in nature and scope, and are applicable to any situation in which the production, sampling, and grading of cauliflower would be undertaken. In effect, the utilized variabls are not unique or contrived. Secondly, the growing and harvesting conditions for the 1973 fall cauliflower season, while not optimum, were not unusual and did afford circumstances that could have caused or contributed to a wider and more realistic range in the variables concerned. Consequently, it has been concluded that these equations are representative of normal growing conditions, and subject to confidence level considerations, applicable and useful for the purpose of predicting the output of a specific frozen cauliflower product. This prediction could ultimately be used as a basis for financial

payment to growers, and as a means of evaluating plant recovery efficiency and quality control.

2. Regression Equations

The following equations were developed as a means of predicting the specific output indicated. Predicted output will be in pounds of finished packed produce in each instance. No distinction is made with regard to the size of the actual containers in which the produce is packed, or the type of pack involved. (Retail, institutional, etc.)

a. Grade A Packout Prediction Equations

(1) When Grade A frozen cauliflower is being processed and packed production output can be predicted with the following equation:

$$\text{Output (lbs.)} = 0.23(\text{TIP}) - 83(\text{SAMBC}) - 157(\text{SAMD}) + 2517$$

This equation is valid providing the following relationship holds:

$$(361)\left(\frac{\text{SAMBC}}{\text{TIP}}\right) + (683)\left(\frac{\text{SAMD}}{\text{TIP}}\right) - (10943)\left(\frac{1}{\text{TIP}}\right) < 1$$

(2) When Grade B frozen cauliflower is being processed and is the primary pack, production output of Grade A packout can be predicted with the following equation:

$$\text{Output (lbs.)} = 105(\text{SAMBC}) - 33(\text{SAMA}) - 219$$

This equation is valid providing the following relationship holds:

$$(0.314)\left(\frac{SAMA}{SAMBC}\right) + 2.09\left(\frac{1}{SAMBC}\right) < 1$$

b. Grade B Packout Prediction Equations

(1) When Grade A frozen cauliflower is being processed and is the primary pack, production output of Grade B packout can be predicted with the following equation:

$$\text{Output (lbs.)} = 42(SAMBC) - 704$$

This equation is valid providing the following relationship holds:

$$SAMBC > 16.76 \text{ lbs.}$$

(2) When Grade B frozen cauliflower is being processed and is the primary pack, production output of Grade B packout can be predicted with the following equation:

$$\text{Output (lbs.)} = 83(SAMWT) - 50(SAMD) - 1451$$

This equation is valid providing the following relationship holds:

$$(0.6024)\left(\frac{SAMD}{SAMWT}\right) + 17.48\left(\frac{1}{SAMWT}\right) < 1$$

c. Pieces Packout Prediction Equation

When either Grade A or Grade B frozen cauliflower is being processed, the total packout of pieces can be predicted with the following equation:

$$\text{Output (lbs.)} = 73(\text{SAMD}) - 22(\text{SAMA}) + 4(\text{SAMWT}) + 214$$

This equation is valid providing the following relationship holds:

$$\left(\frac{1}{\text{SAMA}}\right)[(3.318)(\text{SAMD}) + (0.182)(\text{SAMWT}) + 9.72] > 1$$

### 3. Confidence Levels

The confidence levels for the above equations must be individually determined for each equation on the basis of the values of the variable coefficients involved. Appendix F is provided for this purpose.

## B. FACTORS RELATIVE TO THE SOLUTIONS

### 1. General

During the course of the analysis, several factors that could contribute to the overall accuracy of the equations were identified. Analysis of these factors for their impact on, or inclusion in the regression equations was not possible due to the initial detail of the data recorded. Consequently, it is concluded that further analysis of the part these variables play on cauliflower production may be warranted or desired. These factors are listed below.

### 2. Factors Not Evaluated

#### a. Production Time Lag

The time lag between cutting of the raw produce and its introduction into processing in all probability has a direct bearing on final product output. This is due primarily to deterioration and/or discoloration caused by the

elements while the trailer-borne produce is awaiting processing. The impact of this variable factor could not be properly assessed due to the general nature of the production data retained.

b. Sunlight, Heat, and Moisture Conditions

Combined with the time lag factor outlined in (a) above, the actual environmental conditions to which the raw produce was subjected was not included in the analysis. In addition to the length of time between harvest and processing, the relative intensity of the sunlight, heat and moisture conditions to which the raw produce was exposed, or an interaction of two or more of these factors, could have a bearing on production output quality and quantity. For purposes of this analysis, the assumption was made and generally observed that no extremes in these conditions were encountered. Consequently, the equations account for these factors only in as much as the environmental conditions were average during the harvest and processing periods.

c. Number and Proficiency of Production Workers

The number of production workers assigned to each production segment and their relative level of experience and qualifications was not recorded. As a major portion of the processing evolution and the determination of ultimate quality involves visual sorting of produce, and the manual reduction of the raw vegetable to the recoverable portions, this factor is considered significant. As the same workers were generally involved in all productive segments in this analysis, it was

assumed that there existed little if any variation in their respective proficiencies. However, if variations in these factors were introduced into the situation, namely by the assignment of inexperienced workers to the production process, the validity of the equations could be adversely affected. Likewise, the proficiency of the harvesting crew could prove to be a factor in this analysis. As any proficiency evaluation in these areas would be subjective, it was assumed that the effects of any variations would be minor or self-cancelling, and that an average proficiency prevailed.

## C. SUMMARY

Considering both the theoretical and practical aspects of this study, it was concluded that the equations presented above afford a viable and useful means of predicting ultimate packout and an acceptable alternative to the total packout count method for basing payment to growers for raw produce received. It was further concluded that the levels of confidence inherent in the developed equations were sufficient to warrant consideration of using these equations as predictive means during future processing of cauliflower. However, these conclusions must be regarded as tentative, as evaluation of the degree of impact of several unrecorded variable factors was not possible.

The evolved regression equations, employing selected germaine variables obtained by grading, and applied to input weights as appropriate, possess a degree of reliability

comparable to or surpassing the predictive methods currently employed for other vegetables. Hence, it is maintained that the utility of this sampling-grading system, and its associated regression equations, possesses validity for use as intended, and that the hypothesis of this study is confirmed.

# VI. RECOMMENDATIONS

## A. 1974 FALL HARVEST SEASON

### 1. General

Based on the conclusions presented in Chapter V, it is recommended that consideration be given to utilizing the developed regression equations for predictive output and grower payment purposes during the forthcoming season, especially if grower disenchantment with the total packout count method of payment continues to develop. However, it must be accepted and acknowledged by both parties that this system does not represent a precisely accurate, total solution to this problem, but is a viable, positive step towards establishing a workable and reliable sampling-grading system for subject vegetable. The limitations of this study, the confidence levels obtained, and the implications contained therein, must be understood, and efforts extended to obtain data that would enable refinement and improvement of the overall predictive capacity of the system.

Accurate assessment of the deterioration of raw produce due to prolonged delay between cutting and processing was not possible. Although conclusive evidence was not obtainable during this study, considerable personal opinion was evident which inferred an inverse relationship between total packout count or ultimate quality, and the length of time between harvesting and processing. Consequently, the tentative conclusion was drawn that the significance of this

variable, acting singly or in combination with environmental variables such as heat, sunlight, and moisture should not be ignored. It is recommended that the company and the grower analyze and closely monitor planning and harvesting timing, as well as production schedules, to reduce wherever possible, the period of time between arrival of raw produce at the plant and its introduction into processing. It is acknowledged that this matter has been of major concern to Spiegl Foods' production staff, as well as the growers contracting with Spiegl Foods. Further, it is recommended that both parties undertake research to determine the existence of data or studies in this area of concern, and that any future analysis of this problem include efforts to determine the impact of the variables in question on the predictive equations.

### 2. Procedural Recommendations

During the fall 1974 cauliflower processing season, to whatever extent possible, sampling-grading procedures should be employed in the same manner as the 1973 season, except as modified herein. Although some procedure modifications may involve combining or maintaining additional records, the additional data obtained will assist in building a data base that will facilitate evaluation of the factors beyond the scope of this study, and simplify the usage of the data in its intended functional role within the company.

#### a. Personnel

It is recommended that the two graders who conducted the cauliflower grading operations during the 1973

season be likewise employed during the forthcoming season. If this is not possible, alternate graders should acquire a reasonable degree of experience in the grading of other vegetables before attempting cauliflower grading. Consideration should be given to training an alternate grader under the instruction of the two experienced graders.

b. Procedures

The procedures recommended to be employed are essentially the same as used in the 1973 season. Random samples should be drawn from each load upon its arrival at the plant. It is recommended that the sample size of fifteen heads be retained. A larger sample size would be more appropriate to this situation in light of theoretical considerations only. Increasing the size of the cauliflower sample by any appreciable amount would create a sizable burden on the grading capacities of the firm. Viewed in a practical context, this alternative is regarded as generally unrealistic, and a potentially frustrating and unfruitful recourse. Based on the relatively high confidence levels associated with this analysis obtained by using fifteen head samples, consideration should be given to formulating and recording inputs and production outputs on a more finite and uniform basis. This would tend to reduce the wide deviations in input and output, as well as the size and range of the aggregate samples involved. It is not implied that actual production should be halted for accounting purposes after a certain sized input or individual loads have been introduced and processed. Although desirable,

this would be impractical at best. Rather, the use of existing recording measures, with minor modifications, could be utilized to accomplish the desired results. It must be noted that the wide variations in sample, input, and output sizes used in this study were the result of groupings of data due to production extending over two or more days, and the methods used to record output data in this event. It is proposed that production counts can be, and in fact often are, made daily, accounting for both grower and field identification, and the input and output poundage. Consequently, closer accounting of the inputs, the samples taken, and the output achieved on a daily basis by grower and field will reduce the range of these variables. Inputs that cannot be processed during the day of cutting should be so identified, and the associated samples and output likewise segregated. Adopting this practice, which appears to be within the capacity of the processing department, would reduce the overall size of the primary variables to more uniform levels, and would be a desirable alternative for improving accuracy as opposed to increasing sample size to burdensome and impractical amounts.

Sampling should be conducted when loads arrive at the plant, with the times of cutting and actual sampling recorded on the proposed grading form. Grading should be accomplished as soon after sampling as possible.

Grading should be conducted in the same manner as employed in obtaining the data for this study. The use

or functional adaptation of USDA United States Standards for Cauliflower for Processing is recommended. The five produce grading category weights should be determined to the nearest .25 pound, recorded, and then double-checked to ensure that the sum of the category weights equals the total weight of the sample. The practice of computing category percentages at the grading station is considered unnecessary, and should be eliminated. Grade "A" and any other recoverable produce resulting from the grading should be introduced into processing upon completion of grading.

It is intended that the grading evolution will be threefold in purpose. Firstly, the variables needed for use in the regression equation will be determined. Secondly, production supervisory personnel will be able to confirm their decision on which quality and grade of cauliflower to pack. Thirdly, the data obtained will constitute a data base for future evaluation and possible refinement of this system.

The installation of a Fahrenheit thermometer in the receiving area or the area where loads awaiting introduction into processing are parked is recommended. The purpose of this installation is to provide a means for obtaining the temperature data that will be required to perform an analysis of that element on the possible deterioration of the raw produce.

Additionally, it is recommended that the capacity to obtain and record relative humidity data be acquired. The

use of hourly observations using a sling-psychrometer, or equivalent device, or the hourly observations recorded by FAA facilities, located at the Salinas Municipal Airport, should be adequate for this purpose. Obtaining this measurement will enable evaluation of the effect of moisture on the deterioration of raw produce. Ideally, the observation should be taken in proximity to the trailer loads of produce for best accuracy.

c. Records

The use of the grading sheet contained in Appendix G is recommended. This form consolidates several record entries into one format, and includes previously unrecorded data in a manner that is functional for further analysis, as well as use in predicting the production output. The instructions appended to the form are self-contained. It must be emphasized that the purpose and intent of maintaining these records is to more closely align the primary variables and reduce their size while preventing grouping of data. It is not intended that this system overburden any element of the existing Spiegl Foods's system, but be accomplished within the framework of the existing functional structure.

Raw produce input records and output records should be maintained in the same manner with one exception. Individual input trailer weight records should be taken as done during the 1973 season, but this data should be retained and recorded in order to more closely tabulate input weights with production output.

For analysis of the effect of the number of production lines and workers employed during specific processing evolutions, the records should include the number of production lines utilized and the average total number of personnel involved in the trimming and sorting operations.

All records should be collected and combined at the completion of individual production runs, or production days.

## B. USE OF COMPANY COMPUTER INSTALLATION

It is recommended that Spiegl Foods investigate the use of its computer installation for the purpose of recording and compiling the sample and production data, and computing the predicted output and payment to be rendered, utilizing the appropriate regression coefficients developed above. Further, the use of the inhouse computer installation could facilitate evaluation of the 1974 and future harvest seasons, and procedures could be developed along similar lines to evaluate the effectiveness of the sampling-grading systems applied to vegetables other than cauliflower.

## C. EVALUATION OF THE 1974 FALL CAULIFLOWER HARVEST

The evaluation of the 1974 fall harvest data obtained as recommended above, should be accomplished in the same general manner as the analysis contained in this thesis with appropriate attention devoted to the variables for which evaluation was not possible due to the lack of data. On the basis of this evaluation, the basic equations should be refined as necessary.

# APPENDIX A

## PRODUCTION DATA FOR CASES IN WHICH GRADE "A" CAULIFLOWER WAS THE PACKOUT OBJECTIVE (A-RUN)

| CASE NO | TIP | POA | POB | POP |
|---|---|---|---|---|
| 1 | 56290 | 13740 | 0 | 1000 |
| 2 | 134762 | 36370 | 0 | 1425 |
| 3 | 111550 | 15410 | 7810 | 1365 |
| 4 | 109890 | 25704 | 0 | 655 |
| 5 | 41430 | 9520 | 0 | 625 |
| 6 | 150442 | 33380 | 1405 | 1540 |
| 7 | 64680 | 14454 | 0 | 0 |
| 8 | 130740 | 20280 | 1980 | 0 |
| 9 | 29822 | 5505 | 0 | 0 |
| 10 | 85700 | 16245 | 0 | 0 |
| 11 | 117530 | 32071 | 0 | 0 |
| 12 | 15480 | 3180 | 0 | 0 |
| 13 | 244950 | 39021 | 13917 | 1925 |
| 14 | 131330 | 31011 | 0 | 0 |
| 15 | 88610 | 21274 | 0 | 1200 |
| 16 | 209540 | 50294 | 0 | 495 |
| 17 | 73650 | 12965 | 0 | 2240 |
| 18 | 36084 | 10643 | 0 | 0 |
| 19 | 357992 | 64170 | 0 | 2495 |
| 20 | 86440 | 17340 | 0 | 0 |
| 21 | 54750 | 12240 | 0 | 0 |
| 22 | 186682 | 33034 | 0 | 578 |
| 23 | 89460 | 19123 | 0 | 2900 |
| 24 | 99430 | 21653 | 0 | 0 |
| 25 | 70310 | 13089 | 0 | 950 |
| 26 | 52420 | 7792 | 0 | 920 |
| 27 | 66370 | 17226 | 0 | 0 |
| 28 | 37690 | 11545 | 0 | 985 |
| 29 | 78210 | 25338 | 0 | 640 |

## APPENDIX A (continued)

| CASE NO | TIP | POA | POB | POP |
|---|---|---|---|---|
| 30 | 106800 | 27105 | 372 | 0 |
| 31 | 124290 | 31590 | 0 | 0 |
| 32 | 59050 | 13700 | 0 | 1570 |
| 33 | 84900 | 19942 | 0 | 0 |
| 34 | 113990 | 22692 | 0 | 0 |
| 35 | 157430 | 32478 | 0 | 1925 |
| 36 | 120740 | 26559 | 0 | 0 |
| 37 | 144540 | 29958 | 2592 | 0 |
| 38 | 168760 | 35299 | 0 | 0 |
| 39 | 161682 | 30740 | 0 | 144 |
| 40 | 68380 | 10780 | 0 | 2117 |
| 41 | 33860 | 10305 | 0 | 1083 |
| 42 | 151970 | 17673 | 11636 | 5475 |
| 43 | 73490 | 15342 | 0 | 0 |
| 44 | 58120 | 10140 | 0 | 0 |
| 45 | 99600 | 12770 | 5520 | 1432 |
| 46 | 36610 | 6383 | 0 | 1510 |
| 47 | 122780 | 24573 | 2448 | 1570 |
| 48 | 35780 | 7410 | 984 | 0 |
| | | | | |
| MEAN | 102813 | 21230 | 1014 | 808 |
| STD DEV | 62543 | 12113 | 2884 | 1071 |
| MIN | 15480 | 3180 | 0 | 0 |
| MAX | 357992 | 64170 | 13917 | 5475 |

Notes:

1. This appendix lists the production data associated with the forty-eight cases in which Grade "A" Cauliflower was the primary production objective.
2. The data listed for each case includes: Total Input Weight (TIP); Packout of Grade "A" Cauliflower (POA); Packout of Grade "B" Cauliflower (POB); Packout of Pieces (POP).
3. Unit of measurement for all data: Pounds. ✓

# APPENDIX B

## SAMPLE DATA FOR CASES IN WHICH GRADE "A" CAULIFLOWER WAS THE PACKOUT OBJECTIVE (A-RUN)

| CASE NO. | SAMWT | SAMA | SAMBC | SAMBM | SAMT | SAMD |
|---|---|---|---|---|---|---|
| 1 | 112.50 | 27.00 | 8.00 | 12.25 | 62.50 | 2.75 |
| 2 | 449.50 | 117.50 | 54.25 | 30.00 | 235.25 | 12.50 |
| 3 | 341.25 | 64.00 | 57.25 | 26.50 | 186.50 | 7.00 |
| 4 | 434.50 | 94.75 | 53.50 | 28.50 | 248.50 | 9.25 |
| 5 | 126.00 | 15.75 | 27.75 | 3.75 | 73.25 | 5.50 |
| 6 | 482.25 | 97.25 | 63.50 | 26.25 | 281.00 | 14.25 |
| 7 | 137.25 | 28.75 | 13.50 | 11.50 | 80.00 | 3.50 |
| 8 | 386.50 | 67.25 | 63.00 | 16.50 | 234.50 | 5.25 |
| 9 | 78.25 | 13.25 | 19.00 | 0.75 | 43.00 | 2.25 |
| 10 | 292.25 | 77.75 | 17.50 | 9.25 | 178.25 | 9.50 |
| 11 | 399.50 | 102.00 | 31.25 | 25.75 | 226.50 | 14.00 |
| 12 | 59.25 | 13.75 | 8.50 | 8.50 | 26.25 | 2.25 |
| 13 | 826.75 | 177.25 | 123.25 | 81.25 | 430.00 | 15.00 |
| 14 | 313.00 | 90.50 | 23.25 | 23.50 | 167.50 | 8.25 |
| 15 | 288.50 | 90.75 | 17.25 | 15.75 | 150.75 | 14.00 |
| 16 | 555.00 | 140.25 | 54.75 | 6.75 | 341.50 | 11.75 |
| 17 | 244.50 | 64.50 | 33.50 | 7.75 | 129.50 | 9.25 |
| 18 | 138.01 | 50.25 | 10.63 | 12.50 | 56.88 | 7.75 |
| 19 | 1107.26 | 267.25 | 161.88 | 88.25 | 539.88 | 50.00 |
| 20 | 324.00 | 89.25 | 14.25 | 3.25 | 210.25 | 7.00 |
| 21 | 273.50 | 82.00 | 13.75 | 3.50 | 167.00 | 7.25 |
| 22 | 865.25 | 242.25 | 48.75 | 19.00 | 525.75 | 29.50 |
| 23 | 346.50 | 95.50 | 41.25 | 9.00 | 169.00 | 31.75 |
| 24 | 388.00 | 133.75 | 26.00 | 9.00 | 207.75 | 11.50 |
| 25 | 265.00 | 70.25 | 21.00 | 5.75 | 157.50 | 10.50 |
| 26 | 190.75 | 38.50 | 23.50 | 4.00 | 121.00 | 3.75 |
| 27 | 199.75 | 34.25 | 35.25 | 16.50 | 112.50 | 1.25 |
| 28 | 93.75 | 26.25 | 7.75 | 8.50 | 50.25 | 1.00 |
| 29 | 283.00 | 51.75 | 43.00 | 17.75 | 163.75 | 6.75 |

## APPENDIX B (continued)

| CASE NO. | SAMWT | SAMA | SAMBC | SAMBM | SAMT | SAMD |
|---|---|---|---|---|---|---|
| 30 | 383.75 | 69.75 | 69.50 | 31.75 | 203.75 | 9.00 |
| 31 | 426.75 | 98.50 | 46.25 | 81.00 | 193.00 | 8.00 |
| 32 | 197.25 | 48.00 | 21.50 | 36.75 | 86.25 | 4.75 |
| 33 | 244.00 | 55.75 | 38.25 | 35.75 | 109.25 | 5.00 |
| 34 | 194.50 | 49.75 | 33.50 | 10.00 | 98.00 | 3.25 |
| 35 | 352.25 | 67.25 | 60.75 | 54.00 | 161.75 | 8.50 |
| 36 | 374.75 | 80.00 | 75.50 | 14.50 | 198.25 | 6.50 |
| 37 | 369.25 | 98.25 | 60.00 | 9.25 | 190.50 | 11.25 |
| 38 | 459.25 | 129.25 | 75.50 | 6.75 | 230.25 | 17.50 |
| 39 | 193.25 | 29.50 | 58.50 | 8.50 | 92.50 | 4.25 |
| 40 | 233.25 | 37.25 | 47.00 | 1.50 | 131.00 | 16.50 |
| 41 | 134.25 | 29.25 | 20.00 | 3.50 | 77.75 | 3.75 |
| 42 | 469.75 | 87.75 | 74.75 | 11.75 | 273.00 | 22.50 |
| 43 | 215.50 | 48.25 | 33.25 | 13.75 | 112.00 | 8.25 |
| 44 | 172.75 | 39.50 | 9.25 | 11.50 | 108.00 | 4.50 |
| 45 | 307.25 | 62.25 | 40.25 | 10.00 | 176.50 | 18.25 |
| 46 | 95.75 | 14.50 | 18.25 | 5.25 | 50.75 | 7.00 |
| 47 | 490.75 | 104.00 | 30.75 | 35.75 | 303.25 | 17.00 |
| 48 | 96.75 | 21.50 | 12.25 | 8.75 | 50.25 | 4.00 |
| MEAN | 321.09 | 75.70 | 40.44 | 19.20 | 175.46 | 10.29 |
| STD DEV | 205.89 | 52.83 | 29.77 | 20.16 | 112.61 | 8.85 |
| MIN | 59.25 | 13.25 | 7.75 | 0.75 | 26.25 | 1.00 |
| MAX | 1107.26 | 267.25 | 161.88 | 88.25 | 539.88 | 50.00 |

Notes:

1. This appendix lists the sample data associated with the forty-eight cases in which Grade "A" Cauliflower was the primary production objective. The cases are listed sequentially, and correspond to the production data cases listed in Appendix A.
2. The data listed for each case includes: Sample Weight (SAMWT); Sample Weight of Grade "A" (SAMA); Sample Weight of Grade "B" Color (SAMBC); Sample Weight of Grade "B" Maturity (SAMBM); Sample Weight of Trim Loss (SAMT); Sample Weight of Damage and Rot (SAMD).
3. Unit of Measurement for all data: Pounds.

# APPENDIX C

## PRODUCTION DATA FOR CASES IN WHICH GRADE "B" CAULIFLOWER WAS THE PACKOUT OBJECTIVE (B-RUN)

| CASE NO. | TIP | POA | POB | POP |
|---|---|---|---|---|
| 49 | 89030 | 1920 | 19065 | 0 |
| 50 | 53640 | 1000 | 10500 | 3630 |
| 51 | 298070 | 5727 | 60277 | 10194 |
| 52 | 206010 | 8212 | 46580 | 2560 |
| 53 | 53950 | 510 | 11855 | 1885 |
| 54 | 105850 | 0 | 25668 | 0 |
| 55 | 115280 | 1380 | 33192 | 0 |
| 56 | 101020 | 1152 | 23112 | 0 |
| MEAN | 127856 | 2488 | 28781 | 2234 |
| STD DEV | 83599 | 2901 | 17259 | 3495 |
| MIN | 53640 | 0 | 10500 | 0 |
| MAX | 298070 | 8212 | 60277 | 10194 |

Notes:

1. This appendix lists the production data associated with the eight cases in which Grade "B" Cauliflower was the primary production objective.
2. The data listed for each case includes: Total Input Weight (TIP); Packout of Grade "A" Cauliflower (POA); Packout of Grade "B" Cauliflower (POB); Packout of Pieces (POP).
3. Unit of Measurement for all data: Pounds.

# APPENDIX D

## SAMPLE DATA FOR CASES IN WHICH GRADE "B" CAULIFLOWER WAS THE PACKOUT OBJECTIVE (B-RUN)

| CASE NO. | SAMWT | SAMA | SAMBC | SAMBM | SAMT | SAMD |
|---|---|---|---|---|---|---|
| 49 | 270.50 | 58.25 | 21.00 | 35.50 | 144.00 | 11.75 |
| 50 | 150.50 | 17.00 | 14.00 | 19.00 | 85.50 | 15.00 |
| 51 | 814.00 | 118.00 | 89.75 | 74.50 | 415.50 | 116.25 |
| 52 | 598.25 | 82.75 | 101.50 | 36.00 | 335.25 | 42.75 |
| 53 | 187.50 | 24.25 | 17.25 | 8.25 | 99.00 | 38.75 |
| 54 | 313.00 | 81.00 | 31.50 | 26.00 | 149.75 | 24.75 |
| 55 | 422.50 | 86.50 | 50.50 | 50.50 | 229.00 | 6.00 |
| 56 | 309.25 | 60.50 | 48.00 | 18.00 | 165.50 | 17.25 |
| | | | | | | |
| MEAN | 383.19 | 66.03 | 46.69 | 33.47 | 202.94 | 34.06 |
| STD DEV | 223.26 | 33.52 | 33.17 | 21.13 | 116.91 | 35.60 |
| MIN | 150.50 | 17.00 | 14.00 | 8.25 | 85.50 | 6.00 |
| MAX | 814.00 | 118.00 | 101.50 | 74.50 | 415.50 | 116.25 |

Notes:

1. This appendix lists the sample data associated with the eight cases in which Grade "B" Cauliflower was the primary production objective. The cases are listed sequentially, and correspond to the production data cases listed in Appendix C.
2. The data listed for each case includes: Sample Weight (SAMWT); Sample Weight of Grade "A" (SAMA); Sample Weight of Grade "B" Color (SAMBC); Sample Weight of Grade "B" Maturity (SAMBM); Sample Weight of Trim Loss (SAMT); Sample Weight of Damage and Rot (SAMD).
3. Unit of Measurement for all data: Pounds.

# APPENDIX E

# REGRESSION ANALYSIS

The UCLA (University of California Los Angeles) Biomedical Regression Program (BMD02R) was used to perform the regression analysis.[1] This program computed a series of multiple linear regressions in a stepwise manner. At each step one variable is added or removed from the regression equation. The variable added is the one which makes the greatest reduction in the error sum of the squares between the data points and the regression plane. Actually it is the variable which has the highest partial correlation with the dependent variable given the variables which have already been introduced into the regression, and it is the variable which if added, would have the highest F value. A variable is removed when its F value becomes too low. The stepwise procedure is terminated when all variables are included in the regression equation, or when variables which are not included would produce F values below a present limit or the remaining variables are highly correlated with those in the regression equation. For this study, the F-level required for inclusion was 2.0 and the F-level for deletion was 1.0.

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[1] Dixon, W.J., BMD: Biomedical Computer Programs, 3d ed., p. 233-257d, University of California Press, 1973.

## A. ASSUMPTIONS

Linear regression analysis makes four theoretical assumptions regarding the conditional probability of the dependent variable (Y) and the independent variables ($X_i$):

1. The conditional distributions of Y given X have the same standard deviation no matter what the value of X.
2. The means all lie in the same straight line which is the expression for the true regression line.
3. Successive observations are independent.
4. The values of $X_i$ are known in advance.[2]

## B. PACKOUT OF GRADE "A" WITH A-RUN

A regression analysis was performed on the packout of Grade "A" A-RUN as shown in the following equation, where $a_i$ is the coefficient and the i<sup>th</sup> independent variable and $a_0$ is a constant.

$$POA = a_0 + a_1(TIP) + a_2(SAMWT) + a_3(SAMA) + a_4(SAMBC) + a_5(SAMBM) + a_6(SAMT) + a_7(SAMD)$$

The regression results follow in Table I. The multiple correlation coefficient, R, was high at each step. At the first step of the regression process total raw cauliflower input into production (TIP) became the independent variable. At the second step of the regression process sample weight of Grade "B" color (SAMBC) joined the previously introduced

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[2] Lapin, L.L., Statistics for Modern Business Decisions, p. 466, Harcourt Brace Jovanovich, Inc., 1973.

# TABLE I

## RESULTS OF STEPWISE REGRESSION OF A-RUN PACKOUT OF GRADE "A"

| STEP | 1 | 2 | 3 |
|---|---|---|---|
| Entered | TIP | SAMBC | SAMD |
| Previously Entered | | TIP | SAMBC<br>TIP |
| R | .928 | .933 | .937 |
| **COEFFICIENTS** | | | |
| Constant | 2752.238 | 2501.917 | 2517.278 |
| TIP | .180 | .216 | .230 |
| SAMBC | | -87.197 | -83.234 |
| SAMD | | | -156.650 |
| **STANDARD ERROR OF COEFFICIENTS** | | | |
| TIP | .011 | .022 | .024 |
| SAMBC | | 46.763 | 46.148 |
| SAMD | | | 102.106 |
| **F OF INDEPENDENT VARIABLE** | | | |
| TIP | 285.370 | 94.571 | 94.159 |
| df | 1/46 | 1/45 | 1/44 |
| F(tab., .01) | 7.21 | 7.23 | 7.24 |
| SAMBC | | 3.477 | 3.253 |
| df | | 1/45 | 1/44 |
| F(tab., .10) | | 2.82 | 2.82 |
| SAMD | | | 2.354 |
| df | | | 1/44 |
| F(tab., .20) | | | 1.69 |
| **REGRESSION/RESIDUAL ANALYSIS OF VARIANCE** | | | |
| F | 285.370 | 152.107 | 105.239 |
| df | 1/46 | 2/45 | 3/44 |
| F(tab., .01) | 7.21 | 5.11 | 4.26 |

Notes:

1. $POA = a_0+a_1(TIP)+a_2(SAMWT)+a_3(SAMA)+a_4(SAMBC)+a_5(SAMBM)+a_6(SAMT)+a_7(SAMD)$
2. Sample size = 48
3. F to enter 2.0
4. F to remove 1.0

variable, TIP. On the third step sample weight of damage and rot (SAMD) entered the regression equation. No new variables were introduced after step 3 as the F-statistic for inclusion was below 2.0. When tabulating F-statistics for the 0.99 and 0.95 confidence level, Mathematical Tables from Handbook of Chemistry and Physics was used. All other F-statistics were tabulated using the Handbook of Mathematical Functions.

The F-statistic computed for each separate coefficient, $a_i$, in each step of the regression equation tests the null hypothesis ($H_0$) against the alternate hypothesis ($H_1$):

$$H_0\colon a_i = 0$$

$$H_1\colon a_i \neq 0$$

The null hypothesis should be rejected when the tabulated value of F-statistic at the confidence level $1-\alpha$ is smaller than the F-statistic computed for each coefficient at a specific step in the regression.

The tabulated F-statistics for the independent variables shown in Table I are significant in step 3 for the levels indicated, greater than 0.99 for TIP, greater than 0.90 and less than 0.95 for SAMBC and greater than 0.80 and less than 0.90 for SAMD. In other words there is a 1% risk that the true coefficient for TIP is zero, a less than 10% risk that the true coefficient for SAMBC is zero, and a less than 20% risk that the true coefficient for SAMD is zero.

The analysis of the variance of the regression relationship and the variance of the residuals compare an F-statistic computed for the overall regression relationship with a tabulated F-statistic at the level $1-\alpha$.

$$F_{ij}$$

$i$ = number of degrees of freedom of the regression
$j$ = number of degrees of freedom of the residuals

This procedure tests the null hypothesis ($H_0$) and the alternative hypothesis ($H_1$).

$$H_0: a = 0$$

$$H_1: a \neq 0$$

$$a = \begin{bmatrix} a_1 \\ a_2 \\ \cdot \\ \cdot \\ \cdot \\ a_n \end{bmatrix}$$

$1-n$ = number of independent variables in the regression equation

✓ This procedure, like the F-test for a single coefficient, accepts the null hypothesis when F computed is less than the F tabulated, and rejects the null hypothesis when F computed is larger.

At each step in the regression, as shown in Table I, the computed F-statistic is at least twenty-four times greater than the tabulated F-statistic. Therefore, the overall regression relationship at each step was found to be a significant estimator of the dependent variable, POA, at the greater than 0.99 confidence level.

The following equation was developed as a predictor for packout of grade "A" cauliflower on A-RUN:

$$POA = 2517 + 0.23(TIP) - 83(SAMBC) - 157(SAMD)$$

## C. PACKOUT OF GRADE "A" WITH B-RUN

A regression was performed on the packout of grade "A" for a B-RUN as shown in the following equation:

$$POA = a_0 + a_1(TIP) + a_2(SAMWT) + a_3(SAMA) + a_4(SAMBC) + a_5(SAMBM) + a_6(SAMT) + a_7(SAMD)$$

The regression results follow in Table II. During the first step, sample weight of grade "B" color (SAMBC) was introduced as an independent variable. On step 2, sample weight of grade "A" (SAMA) was also added as an independent variable to the regression equation. No new variables were added as the F-statistics of the remaining variables were too low for inclusion. The null hypothesis, $H_0$: $a_i = 0$, and the alternative hypothesis, $H_1$: $a_i \neq 0$, were tested. It was

## TABLE II

## RESULTS OF STEPWISE REGRESSION OF B-RUN PACKOUT OF GRADE "A"

| STEP | 1 | 2 |
|---|---|---|
| Entered | SAMBC | SAMA |
| Previously Entered | | SAMBC |
| R | .901 | .932 |
| COEFFICIENTS | | |
| Constant | -1189.442 | -219.348 |
| SAMBC | 78.760 | 104.536 |
| SAMA | | - 32.917 |
| STANDARD ERROR OF COEFFICIENTS | | |
| SAMBC | 15.528 | 22.425 |
| SAMA | | 22.190 |
| F OF INDEPENDENT VARIABLE | | |
| SAMBC | 25.726 | 21.730 |
| df | 1/6 | 1/5 |
| F(tab., .01) | 13.74 | 16.26 |
| SAMA | | 2.200 |
| df | | 1/5 |
| F(tab., .20) | | 2.18 |
| REGRESSION/RESIDUAL ANALYSIS OF VARIANCE | | |
| F | 25.726 | 16.537 |
| dF | 1/6 | 2/5 |
| F(tab., .01) | 13.74 | 13.27 |

Notes:

1. $POA = a_0 + a_1(TIP) + a_2(SAMWT) + a_3(SAMA) + a_4(SAMBC) + a_5(SAMBM) + a_6(SAMT) + a_7(SAMD)$
2. Sample size = 8
3. F to enter 2.0
4. F to remove 1.0

determined that SAMBC was significant at the level of greater than 0.99 and SAMA was significant at a level of greater than 0.80 and less than 0.90. In the analysis of variance the overall regression relationship at each step was found to be a significant estimator of the dependent variable, POA, at a greater than 0.99 confidence level.

The following regression equation was developed as a predictor for the packout of grade "A" cauliflower on a B-RUN:

$$\text{POA} = -219 + 105(\text{SAMBC}) - 33(\text{SAMA})$$

## D. PACKOUT OF GRADE "B" WITH A-RUN

A regression analysis was performed on the packout of grade "B" A-RUN as shown in the following equation:

$$\text{POB} = a_0 + a_1(\text{TIP}) + a_2(\text{SAMWT}) + a_3(\text{SAMA}) + a_4(\text{SAMBC}) + a_5(\text{SAMBM}) + a_6(\text{SAMT}) + a_7(\text{SAMD})$$

The results of the regression follow in Table III. The regression went through only one step. Only one independent variable (SAMBC) was introduced into the regression equation. All other variables had a F-statistic below 2.0. Again testing the null hypothesis, $H_0$: $a_i = 0$, and the alternative hypothesis, $H_1$: $a_i \neq 0$, it was found that SAMBC was significant at a level greater than 0.99. Likewise in the analysis of variance it was found that the computed F-statistic is

# TABLE III

## RESULTS OF STEPWISE REGRESSION OF A-RUN PACKOUT OF GRADE "B"

| STEP | 1 |
|---|---|
| Entered | SAMBC |
| R | .438 |
| COEFFICIENTS | |
| Constant | -703.788 |
| SAMBC | 42.476 |
| STANDARD ERROR OF COEFFICIENT | |
| SAMBC | 12.838 |
| F OF INDEPENDENT VARIABLE | |
| SAMBC | 10.947 |
| df | 1/46 |
| F(tab., .01) | 7.21 |
| REGRESSION/RESIDUAL ANALYSIS OF VARIANCE | |
| F | 10.947 |
| df | 1/46 |
| F(tab., .01) | 7.21 |

Notes:

1. $POB = a_0+a_1(TIP)+a_2(SAMWT)+a_3(SAMA)+a_4(SAMBC)+a_5(SAMBM)$
   $+a_6(SAMT)+a_7(SAMD)$
2. Sample size = 48
3. F to enter 2.0
4. F to remove 1.0

one and one-half times greater than the tabulated F-statistic. The overall regression relationship was found to be a significant estimator of the dependent variable, POB, at a greater than 0.99 confidence level. The following equation was developed as a predictor for packout of grade "B" cauliflower on a B-RUN:

$$POB = -704 + 42(SAMBC)$$

## E. PACKOUT OF GRADE "B" WITH B-RUN

A regression analysis was performed on the packout of grade "B" B-RUN as shown in the following equation:

$$POB = a_0 + a_1(TIP) + a_2(SAMWT) + a_3(SAMA) + a_4(SAMBC) + a_5(SAMBM) + a_6(SAMT) + a_7(SAMD)$$

The results are displayed in Table IV. The regression went through two steps before the F values of the remaining variables dropped below 2.0. The two variables which were introduced as independent variables in the regression equation were: total pounds sampled (SAMWT) and sample damage and rot (SAMD). The null hypothesis, $H_0$: $a_i = 0$, and the alternative hypothesis, $H_1$: $a_i \neq 0$, were again tested. It was found that SAMWT was significant at the greater than 0.99 level and SAMD was significant at the greater than 0.90 and less than the 0.95 level. In the analysis of variance

## TABLE IV

## RESULTS OF STEPWISE REGRESSION OF B-RUN PACKOUT OF GRADE "B"

| STEP | 1 | 2 |
|---|---|---|
| Entered | SAMWT | SAMD |
| Previously Entered | | SAMWT |
| R | .996 | .998 |
| COEFFICIENTS | | |
| Constant | -725.844 | -1451.155 |
| SAMWT | 77.004 | 83.384 |
| SAMD | | - 50.474 |
| STANDARD ERROR OF COEFFICIENTS | | |
| SAMWT | 2.780 | 3.464 |
| SAMD | | 21.727 |
| F OF INDEPENDENT VARIABLE | | |
| SAMWT | 767.351 | 549.345 |
| df | 1/6 | 1/5 |
| F(tab., .01) | 13.74 | 13.27 |
| SAMD | | 5.397 |
| df | | 1/5 |
| F(tab., .10) | | 4.09 |
| REGRESSION/RESIDUAL ANALYSIS OF VARIANCE | | |
| F | 767.351 | 667.521 |
| df | 1/6 | 2/5 |
| F(tab., .01) | 13.74 | 13.27 |

Notes:

1. $POB = a_0+a_1(TIP)+a_2(SAMWT)+a_3(SAMA)+a_4(SAMBC)+a_5SAMBM) +a_6(SAMT)+a_7(SAMD)$
2. Sample size = 8
3. F to enter 2.0
4. F to remove 1.0

the computed F-statistic was at least forty-eight times greater than the tabulated F-statistic. The overall regression relationship at each step was found to be a significant estimator of the dependent variable, POB, at the greater than 0.99 confidence level. The following equation was developed as a predictor for the packout of grade "B" with B-RUN:

$$POB = -1451 + 83(SAMWT) - 50(SAMD)$$

## F. PACKOUT OF PIECES

Regression analysis was performed on the packout of pieces as shown in the following equation:

$$POP = a_0 + a_1(TIP) + a_2(SAMWT) + a_3(SAMA) + a_4(SAMBC) + a_5(SAMBM) + a_6(SAMT) + a_7(SAMD)$$

The results follow in Table V. During the first step the independent variable SAMD was introduced into the regression equation. The regression progressed through a total of three steps during which SAMA and SAMWT were also introduced into the regression equation as independent variables. When the null hypothesis, $H_0$: $a_i = 0$, and the alternative hypothesis, $H_1$: $a_i \neq 0$, were tested it was found that SAMD was significant at the 0.99 level, SAMA and SAMWT were significantly greater than 0.95 and less than 0.99 level. In the analysis

## TABLE V

## RESULTS OF STEPWISE REGRESSION OF PACKOUT OF PIECES

| STEP | 1 | 2 | 3 |
|---|---|---|---|
| Entered | SAMD | SAMA | SAMWT |
| Previously Entered | | SAMD | SAMA<br>SAMD |
| R | .803 | .827 | .841 |
| **COEFFICIENTS** | | | |
| Constant | -46.485 | 375.759 | 214.273 |
| SAMD | 77.803 | 87.128 | 73.096 |
| SAMA | | - 7.399 | - 21.784 |
| SAMWT | | | 4.312 |
| **STANDARD ERROR OF COEFFICIENTS** | | | |
| SAMD | 7.869 | 8.294 | 10.657 |
| SAMA | | 2.844 | 7.658 |
| SAMWT | | | 2.140 |
| **F OF INDEPENDENT VARIABLE** | | | |
| SAMD | 97.758 | 110.342 | 47.048 |
| df | 1/54 | 1/53 | 1/52 |
| F(tab., .01) | 7.13 | 7.14 | 7.15 |
| SAMA | | 6.766 | 8.092 |
| df | | 1/53 | 1/52 |
| F(tab., .05) | | 4.02 | 4.02 |
| SAMWT | | | 4.058 |
| df | | | 1/52 |
| F(tab., .05) | | | 4.02 |
| **REGRESSION/RESIDUAL ANALYSIS OF VARIANCE** | | | |
| F | 97.758 | 57.482 | 41.885 |
| df | 1/54 | 2/53 | 3/52 |
| F(tab., .01) | 7.13 | 5.03 | 4.18 |

Notes:

1. $POP = a_0 + a_1(TIP) + a_2(SAMWT) + a_3(SAMA) + a_4(SAMBC) + a_5(SAMBM) + a_6(SAMT) + a_7(SAMD)$
2. Sample size = 56
3. F to enter 2.0
4. F to remove 1.0

of variance it was determined that in each step of the regression the computed F-statistic was at least ten times greater than the tabulated F-statistic. Therefore, the overall regression relationship at each step was found to be a significant estimator of the dependent variable, POP, at the greater than 0.99 confidence level. Regardless of whether it is a grade "A" or grade "B" production run the following equation was developed as a predictor for the packout of pieces:

$$POP = 214 + 73(SAMD) - 22(SAMA) + 4(SAMWT).$$

# APPENDIX F

## 1. GENERAL

Confidence levels for the predicted output (Y) can be derived using the following data and information. A confidence level is the proportion of interval estimates obtained from many repeated samples (of the same size) taken from the same population, that will contain the actual output being estimated. For example, suppose that the confidence level is set at 95%. If one was to repeat the sampling procedures, then on the average 95 out of every 100 similar intervals obtained would contain the actual Y while five intervals would not contain the actual Y.

Confidence levels for the predicted output (Y) can be derived by the following:[3]

$$(1\ x\ y\ z)\quad \left[A_{i,j}\right]\begin{pmatrix}1\\x\\y\\z\end{pmatrix} = S^2(E[Y])$$

$$[S^2(E[Y]) + 1]\ \mathrm{MSE} = S^2(Y)$$

$$Y = a_0 + a_1x + a_2y + a_3z$$

$$Y \pm t_{df}\ (\alpha/2)\ \sqrt{S^2(Y)}$$

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[3] Neter, J. and Wasserman, W., Applied Linear Statistical Models, p. 233, Richard D. Irwin, Inc., 1974.

df of residual or n - # of coefficients

$A_{i,j}$ = inverse of the information matrix of the regression as given on the following pages

MSE = residual sum of squares/df

## 2. PACKOUT OF GRADE "A" WITH A-RUN

$$\begin{array}{c|cccc} & 1 & \mathrm{SAMD} & \mathrm{SAMBC} & \mathrm{TIP} \\ \hline 1 & 0.0792479951 & -0.0000533178 & 0.0003192608 & -0.0000006884 \\ \mathrm{SAMD} & -0.0000533178 & 0.0005438681 & -0.0000137614 & -0.0000000485 \\ \mathrm{SAMBC} & 0.0003192608 & -0.0000137614 & 0.0001110937 & -0.0000000454 \\ \mathrm{TIP} & -0.0000006884 & -0.0000000485 & -0.0000000454 & 0.0^{10}2941700 \end{array} = A_{i,j}$$

MSE = 19169488

$$\begin{pmatrix} 1 & \mathrm{SAMD} & \mathrm{SAMBC} & \mathrm{TIP} \end{pmatrix} \begin{bmatrix} A_{i,j} \end{bmatrix} \begin{pmatrix} 1 \\ \mathrm{SAMD} \\ \mathrm{SAMBC} \\ \mathrm{TIP} \end{pmatrix} = S^2(E[Y])$$

$$[S^2(E[Y]) + 1]\ 19169488 = S^2(Y)$$

df = 44

$$Y = 2517 - 157(\mathrm{SAMD}) - 83(\mathrm{SAMBC}) + .23(\mathrm{TIP})$$

$$Y \pm t_{44}(\alpha/2)\sqrt{S^2(Y)}$$

### 3. PACKOUT OF GRADE "A" WITH B-RUN

$$\begin{array}{l} \\ 1 \\ \text{SAMBC} \\ \text{SAMA} \end{array} \begin{array}{c} \begin{array}{ccc} 1 & \text{SAMBC} & \text{SAMA} \end{array} \\ \begin{bmatrix} 0.6844880784 & 0.0012823893 & -0.0093797956 \\ 0.0012823893 & 0.0003250366 & -0.0002492386 \\ -0.0093797956 & -0.0002492386 & 0.0003182754 \end{bmatrix} \end{array} = A_{i,j}$$

MSE = 1547204

$$(1 \quad \text{SAMBC} \quad \text{SAMA}) \begin{bmatrix} A_{i,j} \end{bmatrix} \begin{pmatrix} 1 \\ \text{SAMBC} \\ \text{SAMA} \end{pmatrix} = S^2(E[Y])$$

$$[S^2(E[Y]) + 1]\ 1547204 = S^2(Y)$$

df = 5

$$Y = -219 + 105(\text{SAMBC}) - 33(\text{SAMA})$$

$$Y \pm t_5(\alpha/2)\sqrt{S^2(Y)}$$

## 4. PACKOUT OF GRADE "B" WITH A-RUN

$$\begin{array}{c|cc} & 1 & \text{SAMBC} \\ \hline 1 & 0.0209701925 & -0.0000386206 \\ \text{SAMBC} & -0.0000386206 & 0.0000083782 \end{array} = A_{i,j}$$

MSE = 6864634

$$(1 \quad \text{SAMBC}) \begin{bmatrix} A_{i,j} \end{bmatrix} \begin{pmatrix} 1 \\ \text{SAMBC} \end{pmatrix} = S^2(E[Y])$$

$$[S^2(E[Y]) + 1]\ 6864634 = S^2(Y)$$

df = 46

$$Y = -704 + 42(\text{SAMBC})$$

$$Y \pm t_{46}(\alpha/2)\sqrt{S^2(Y)}$$

## 5. PACKOUT OF GRADE "B" WITH B-RUN

$$\begin{array}{c} \\ 1 \\ \mathrm{SAMWT} \\ \mathrm{SAMD} \end{array} \begin{array}{c} \begin{array}{ccc} 1 & \mathrm{SAMWT} & \mathrm{SAMD} \end{array} \\ \begin{bmatrix} 0.6084612291 & 0.0043596103 & -0.0016492199 \\ 0.0043596103 & 0.0003033844 & 0.0000383458 \\ -0.0016492199 & -0.0000383458 & 0.0000077126 \end{bmatrix} \end{array} = A_{i,j}$$

MSE = 1556048

$$(1 \quad \mathrm{SAMWT} \quad \mathrm{SAMD}) \begin{bmatrix} A_{i,j} \end{bmatrix} \begin{pmatrix} 1 \\ \mathrm{SAMWT} \\ \mathrm{SAMD} \end{pmatrix} = S^2(E[Y])$$

$$[S^2(E[Y]) + 1]\ 1556048 = S^2(Y)$$

df = 5

$$Y = -1451 + 83(\mathrm{SAMWT}) - 50(\mathrm{SAMD})$$

$$Y \pm t_5(\alpha/2)\sqrt{S^2(Y)}$$

## 6. PACKOUT OF PIECES

$$\begin{array}{c} \\ \text{1} \\ \text{SAMWT} \\ \text{SAMA} \\ \text{SAMD} \end{array} \begin{array}{cccc} \text{1} & \text{SAMWT} & \text{SAMA} & \text{SAMD} \\ \end{array}$$

$$\begin{array}{c|cccc} & 1 & \text{SAMWT} & \text{SAMA} & \text{SAMD} \\ \hline 1 & 0.0653402159 & -0.0001975002 & 0.0001564363 & 0.0004426250 \\ \text{SAMWT} & -0.0001975002 & 0.0000052730 & -0.0000175927 & -0.0000171608 \\ \text{SAMA} & 0.0001564363 & -0.0000175927 & 0.0000675005 & 0.0000461576 \\ \text{SAMD} & 0.0004426250 & -0.0000171608 & 0.0000461576 & 0.0001307278 \end{array} = A_{1,j}$$

$\text{MSE} = 868674$

$$(1 \quad \text{SAMWT} \quad \text{SAMA} \quad \text{SAMD}) \begin{bmatrix} A_{i,j} \end{bmatrix} \begin{pmatrix} 1 \\ \text{SAMWT} \\ \text{SAMA} \\ \text{SAMD} \end{pmatrix} = S^2(E[Y])$$

$$[S^2(E[Y]) + 1]\ 868674 = S^2(Y)$$

$\text{df} = 52$

$$Y = 214 + 4(\text{SAMWT}) - 22(\text{SAMA}) + 73(\text{SAMD})$$

$$Y \pm t_{52}(\alpha/2)\sqrt{S^2(Y)}$$

# APPENDIX G

## INSTRUCTIONS FOR PREPARING THE CAULIFLOWER GRADING FORM

General. The attached form represents an effort to collect all existing variable data associated with specific production runs of frozen cauliflower. It contains twenty (20) variables (blanks), the majority of which have been previously recorded by other means, and a few new data items. Specific instructions and responsibilities for the various inputs are listed below. The form is an integral part of establishing a data base that will be used to evaluate existing cauliflower grading procedures. Consequently, practical accuracy is desired.

General Instructions.

1. Weights: Input and output weights should be the actual weights accurate to the nearest pound.
2. Sample Weights: Accuracy to the nearest .25 pounds is desired.
3. Times: Use local times, with "A" for AM and "P" for PM.
4. Weather Data: Subjective judgment and general observations will be adequate. A thermometer and psychrometer have been provided in the receiving for recording data.

Specific Instructions;

| Item | Responsibility | Instructions |
|---|---|---|
| A. | Receiving Dept. | Self-explanatory |
| B. | Receiving Dept. | Self-explanatory |
| C. | Receiving Dept. | Record total produce weight of load. |
| D. | Receiving Dept. | Record time that load arrives at the plant. |
| E. | Graders | Self-explanatory |
| F. | Processing | Self-explanatory |
| G. through L. | Graders | Record sample weights only. |
| M. | Processing Dept. | Record average numbers |
| N. through P. | Processing | Output count: Daily count total for the load inputs recorded. |
| Q. and R. | Graders | Enter appropriate number that describes the conditions while the load was awaiting processing. |
| S. | Graders | Use average temperature during the same period as Q. and R. |
| T. | Graders | Use Relative Humidity for same period. |

RAW CAULIFLOWER GRADING/PRODUCTION FORM

DATE ____________

| LOAD IDENTIFICATION | | LOAD WEIGHT | TIME DATA | | | SAMPLE DATA | | | | | | PRODUCTION DATA | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R | P | R | R | G | P | G | G | G | G | G | G | P | P | P | P | G | G | G | G |
| A. Grower/ Field | B. Load No.<br>—<br>Trailer Nos. | C. Load Weight in Pounds | D. Time/ Date Load Arrival | E. Time/ Date Sample Drawn | F. Time/ Date Proces. Begun | G. Sample Weight 15 Heads | H. Grade "A" Weight | I. Grade "B" Color Weight | J. Grade "B" Maturity Weight | K. Rot and Damage Weight | L. Trim Loss Weight | M. Prod. Lines & No. of Personnel | N. Output Grade "A" | O. Output Grade "B" | P. Output Pieces | Q. Weather<br>1. Clear<br>2. Cloudy | R. Rain<br>0. None<br>1. Light<br>2. Moderate<br>3. Heavy | S. Aver. Temp. | T. Rel. Humidity |
| I/H<br>13 | 123456<br>—<br>654<br>321 | 4000 | 1015A<br>12 Oct | 11:30A<br>12OCT | 12:30P<br>12OCT | 57.50 | 20.00 | 1.00 | 0 | 1.25 | 35.25 | 2<br>—<br>30 | | | | 1. | 0 | 75° | .40 |
| I/H<br>13 | | | | | | | SAMPLE ENTRY | | | | | | | | | | | | |
| I/H<br>13 | | | | | | | | | | | | | | | | | | | |
| I/H<br>13 | | | | | | | | | | | | | | | | | | | |
| I/H<br>13 | | | | | | | | | | | | | | | | | | | |
| I/H<br>13 | | | | | | | | | | | | | | | | | | | |
| I/H<br>13 | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | DAILY SUM | 850# | 0 | 0 | | | | |

DATA RESPONSIBILITIES:

R = Receiving Dept.
G = Graders
P = Processing Dept.

DATA RESPONSIBILITIES:

R = Receiving Dept.
G = Graders
P = Processing Dept.

# APPENDIX H

## UNITED STATES STANDARDS FOR CAULIFLOWER FOR PROCESSING[4,5]

(24 F.R. 6238)
Effective September 4, 1959

OUTLINE:

GRADE

Sec.
51.3220 U.S. No. 1.

CULLS
51.3221 Culls.

BASIS OF GRADING CAULIFLOWER
51.3222 Basis of grading cauliflower.

APPLICATION OF STANDARDS
51.3223 Application of standards.

DEFINITIONS
51.3224 Fresh.
51.3225 Compact.
51.3226 Characteristic Color.
51.3227 Cull Material.
51.3228 Damage
51.3229 Diameter.
51.3230 Segment

AUTHORITY: §§51.3220 to 51.3230 issued under secs. 202-208, 60 Stat. 1087, as amended; 7 U.S.C. 1621-1627.

## GRADE

§51.3220 U.S. No. 1.

"U.S. No. 1" consists of cauliflower which is fresh, compact, which has good characteristic color and is free from jacket leaves, stalks and other cull material, soft or wet

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[4] Published by U.S. Department of Agriculture, Agricultural Marketing Service, Washington, D.C.

[5] Packing of the product in conformity with the requirements of these standards shall not excuse failure to comply with the provisions of the Federal Food, Drug, and Cosmetic Act.

decay, and free from damage caused by discoloration, bruising, riciness, fuzziness, enlarged bracts, dirt or other foreign material, mildew or other disease, insects, freezing, hail, or mechanical or other means.

(a) Unless otherwise specified, each head shall be not less than 4 inches in diameter.

## CULLS

### §51.3221 Culls.

"Culls" consist of cauliflower which fails to meet the requirements of the foregoing grade, other than for size.

## BASIS OF GRADING CAULIFLOWER

### §51.3222 Basis of grading cauliflower.

In grading cauliflower the head is cored and quartered. The defective segments are then removed from the head and classed as culls. (See §51.3230.)

## APPLICATION OF STANDARDS

### §51.3223. Application of standards.

In the application of this grade to determine the percentage of the log which meets the requirements of U.S. No. 1 grade, tolerances shall not apply. When a lot is required to meet U.S. No. 1 grade, the following tolerances, by weight, shall apply:

(a) Tolerances for defects. 10 percent for cauliflower which fails to meet the requirements of the grade, other than for size: Provided, That not more than one-fifth of this amount, or 2 percent, shall be allowed for cauliflower affected by soft or wet decay; and,

(b) Tolerance for size. Not more than 5 percent of any lot shall be allowed for heads failing to meet the specified minimum size.

## DEFINITIONS

§51.3224 Fresh.

"Fresh" means that the head is not more than slightly wilted.

§51.3225 Compact.

"Compact" means that the flower clusters of the head or segments of the head are tightly united.

§51.3226 Characteristic color.

"Characteristic color" means that the head or segments of the head are white or creamy white.

§51.3227 Cull material.

"Cull material" means jacket leaves and stems removed in the proper trimming of the heads and any loose leaves or foreign material.

## §51.3228 Damage.

"Damage", unless otherwise specifically defined in this section, means any defect which materially affects the appearance, or the processing quality of the cauliflower. Any one of the following defects, or any combination of defects the seriousness of which exceeds the maximum allowed for any one defect, shall be considered as damage:

(a) Discoloration when the cauliflower is of some abnormal color which will not change to a white or light cream color in the ordinary process of blanching;

(b) Riciness when individual bud branches have become slightly elongated and flower clusters have lost compactness to the extent that a granular or abnormally rough surface is apparent;

(c) Enlarged leaf bracts (modified ingrown leaves) when a segment has:

(1) More than 3 light green leaf bracts extending over the shoulder of the segment;

(2) One light green leaf bract extending more than half way across the segment; or,

(3) Any leaf bract darker in color than light green; and,

(d) Insects when there is more than slight infestation or when the cauliflower is blemished by feeding or other means to the extent that the appearance or processing quality is materially affected.

§51.3229. Diameter.

"Diameter" means the greatest dimension of the head measured at right angles to a line running from the crown to the base of the head, exclusive of the jacket leaves.

§51.3230 Segment.

"Segment" means one of the principal divisions of the head, consisting of a primary branch of the stem, including secondary branches and flower buds.

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The United States Standards for Cauliflower for Processing contained in this subpart shall become effective 30 days after publication hereof in the FEDERAL REGISTER.

Dated: July 30, 1959

ROY W. LENNARTSON,
Deputy Administrator,
Marketing Services.

[F.R. Doc. 59-6371; Filed, Aug. 3, 1959; 8:45 a.m.]

# UNITED STATES STANDARDS FOR GRADES OF FROZEN CAULIFLOWER[6,7]

Effective November 12, 1951[8]

OUTLINE:

## PRODUCT DESCRIPTION AND GRADES

Sec.
52.721 Product description.
52.722 Grades of frozen cauliflower.

## FACTORS OF QUALITY

52.723 Ascertaining the grade.
52.724 Ascertaining the rating for the factors which are scored.
52.725 Color.
52.726 Absence of defects.
52.727 Character

## LOT INSPECTION AND CERTIFICATION

52.728 Ascertaining the grade of a lot.

## SCORE SHEET

52.729 Score sheet for frozen cauliflower.

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[6] Published by U.S. Department of Agriculture, Agricultural Marketing Service, Washington, D.C.

[7] The requirements of these standards shall not excuse failure to comply with the provisions of the Federal Food, Drug, and Cosmetic Act.

[8] This is the third issue of the United States Standards for Grades of Frozen Cauliflwoer. These standards are issued by the Department after careful consideration of all data and views submitted.

These standards were recodified in the Federal Register of December 9, 1953 (18 F.R. 7953) and no change was made except in the format. Section 52.728 was amended (22 F.R. 3535) to become effective July 1, 1957.

As in the case of other standards for processed fruits and vegetables, these standards are designed to serve as a convenient basis for sales, for establishing quality control programs, and for determining load values. They will also

## PRODUCT DESCRIPTION AND GRADES

§52.721 Product Description.

Frozen cauliflower is prepared from the fresh flower heads of the cauliflower plant (Brassica oleracea botrytis) by trimming, washing, and blanching and is frozen and maintained at temperatures necessary for preservation of the product.

§52.722 Grades of frozen cauliflower.

(a) "U.S. Grade A" or "U.S. Fancy" is the quality of frozen cauliflower that possesses similar varietal characteristics; that possesses a good flavor and odor; that possesses a good color; that is practically free from defects; that possesses a good character; and that scores not less than 85 points when scored in accordance with the scoring system outlined in this subpart.

(b) "U.S. Grade B" or "U.S. Extra Standard" is the quality of frozen cauliflower that possesses similar varietal characteristics; that possesses a fairly good flavor and odor;

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serve as a basis for the inspection of this commodity by Federal inspection service, which is available for the inspection of other processed products as well.

The Department welcomes suggestions which might aid in improving these standards in future revisions. Comments may be submitted to, and copies of these standards obtained from:

Chief, Processed Products Standardization
and Inspection Branch
Fruit and Vegetable Division
Agricultural Marketing Service
United States Department of Agriculture
Washington 25, D.C.

that possesses a reasonably good color; that is reasonably free from defects; that possesses a reasonably good character; and that scores not less than 70 points when scored in accordance with the scoring system outlined in this subpart.

(c) "Substandard" is the quality of frozen cauliflower that fails to meet the requirements of U.S. Grade B or U.S. Extra Standard.

## FACTORS OF QUALITY

### §52.723 Ascertaining the grade.

(a) The grade of frozen cauliflower is ascertained by considering, in conjunction with the requirements of the respective grade, the respective ratings for the factors of color, absence of defects, and character.

(b) The relative importance of each factor which is scored is expressed on the scale of 100. The maximum number of points that may be given such factors are:

| Factors: | Points |
|---|---|
| Color -------------------- | 40 |
| Absence of defects ------ | 40 |
| Character --------------- | 20 |
| Total score ---------- | 100 |

(c) The scores for the factors of color, absence of defects, and character are determined immediately after thawing so that the product is sufficiently free from ice crystals to permit proper handling as individual units, except

that buds or buttons which are slightly dark in typical color are cooked before evaluating the factor of color. The product is cooked to determine the flavor and odor.

(d) "Good flavor and odor" means that the product after cooking has a good, characteristic, normal flavor and odor and is free from objectionable flavors and objectionable odors of any kind.

(e) "Fairly good flavor and odor" means that the product after cooking may be lacking in good flavor and odor but is free from objectionable flavors and objectionable odors of any kind.

## §52.724 Ascertaining the rating for the factors which are scored.

The essential variations within each factor which is scored are so described that the value may be ascertained for each factor and expressed numerically. The numerical range within each factor which is scored is inclusive (for example, "17 to 20 points" means 17, 18, 19, or 20 points).

## §52.725 Color

(a) "A" classification. Frozen cauliflower that possesses a good color may be given a score of 34 to 40 points. "Good color" means that the buds or buttons possess a characteristic white to light cream color over the tops, which color may be slightly variable, and that the product may possess a characteristic green color or bluish tint on the branches and greenish yellow to light green modified leaves or bracts:

Provided, That the buds or buttoms may possess a color slightly darker than light cream which disappears upon cooking.

(b) "B" classification. If the frozen cauliflower possesses a reasonably good color, a score of 28 to 33 points may be given. Frozen cauliflower that falls into this classification shall not be graded above U.S. Grade B or U.S. Extra Standard, regardless of the total score for the product (this is a limiting rule). "Reasonably good color" means that the buds or buttons may possess a variable characteristic color ranging from white or light cream to dull white or dark cream over the tops, and that the product may possess a characteristic green color or bluish tint on the branches and greenish yellow to light green modified leaves or bracts: Provided, That the buds or buttons may possess a color darker than dark cream, but not seriously darkened, which color disappears upon cooking to the extent that the appearance of the product is no more than slightly affected.

(c) "SStd" classification. Frozen cauliflower that is off color for any reason or that fails to meet the requirements of paragraph (b) of this section may be given a score of 0 to 27 points and shall not be graded above Substandard, regardless of the total score for the product (this is a limiting rule).

### §52.726 Absence of defects

(a) General. The factor of absence of defects refers to the degree of freedom from poorly trimmed clusters and small

clusters, from damaged and seriously damaged clusters and small clusters, from pieces and detached fragments, and from any other defects which detract from the appearance or edibility of the product.

(1) "Portion of a head" means an individual portion or section of a head made up of buds or buttons and the adjoining stems or portions of stems and attached modified leaves or bracts.

(2) "Cluster" means a portion of a head which weights more than 1/4 ounce and which is not less than 3/4 inch in the greatest dimension measured across the top of the cluster.

(3) "Small cluster" means a portion of a head which weights not more than 1/4 ounce and which is not less than 3/4 inch in the greatest dimension measured across the top of the cluster.

(4) "Piece" means a small portion of a head which is less than 3/4 inch in the greatest dimension measured across the top of the cluster. "Pieces" are considered as defects whether or not defective.

(5) "Detached fragments" are detached leaves, detached modified leaves or bracts, or detached portions of stems. Detached fragments are considered as defects whether or not defective.

(6) "Poorly trimmed cluster" or "poorly trimmed small cluster" means that the appearancy of the cluster is seriously affected by ragged cutting or gouging, or both, or is seriously affected by attached modified leaves or bracts.

(7) "Damaged cluster" or "damaged small cluster" means that the cluster is damaged by dark discoloration, pathological injury, insect injury, or any other injury or defect which singly or in combination affect materially the appearance or edibility of the cluster.

(8) "Seriously damaged cluster" or "seriously damaged small cluster" means that the cluster is damaged to the extent that the appearance or edibility of the cluster is seriously affected.

(b) "A" classification. Frozen cauliflower that is practically free from defects may be given a score of 34 to 40 points. "Practically free from defects" means that the product is practically free from pieces and detached fragments and from any defects not specifically mentioned that affect materially the appearance or edibility of the product, and, in addition, means that:

(1) No seriously damaged clusters are presented and

(2) Not more than a total of 15 percent, by weight, of the cauliflower may be poorly trimmed clusters, poorly trimmed small clusters, damaged clusters, damaged small clusters, and seriously damaged small clusters: Provided, Not more than 10 percent, by weight, of the cauliflower are damaged clusters,[9] damaged small clusters, and seriously

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[9] One cluster in a single container is permitted to be damaged if such cluster exceeds 10 percent, by weight, provided that in all containers comprising the sample, such damaged cluster does not exceed an average of 10 percent by weight.

damaged small clusters: Further provided, Not more than 5 percent, by weight, of the cauliflower are seriously damaged small clusters.

(c) "B" classification. If the frozen cauliflower is reasonably free from defects, a score of 28 to 33 points may be given. Frozen cauliflower that falls into this classification shall not be graded above U.S. Grade B or U.S. Extra Standard, regardless of the total score for the product (this is a limiting rule). "Reasonably free from defects" means that the product is reasonably free from pieces and detached fragments and from any defects not specifically mentioned that affect seriously the appearance or edibility of the product, and in addition, means that:

(1) Not more than a total of 30 percent, by weight, of the cauliflower may be poorly trimmed clusters, poorly trimmed small clusters, damaged clusters, damaged small clusters, seriously damaged clusters, and seriously damaged small clusters: Provided, Not more than 15 percent, by weight, of the cauliflower are damaged clusters, damaged small clusters, seriously damaged clusters, seriously damaged small clusters: Further provided, Not more than 10 percent, by weight, of the cauliflower are seriously damaged clusters and seriously damaged small clusters.

(d) "SStd" classification. Frozen cauliflower that fails to meet the requirements of paragraph (c) of this section may be given a score of 0 to 27 points and shall not be graded above Substandard, regardless of the total score for the product (this is a limiting rule).

## §52.727 Character

(a) General. The factor of character refers to the development, texture, and degree of freedom from ricey and fuzzy units.

(1) "Ricey units" are sections of the head on which the ultimate branches have become elongated, causing the flower clusters to separate and present a loose or open and sometimes granular appearancy.

(2) "Fuzzy units" are sections of the head that have elongated individual flowers or pedicels that result in a very fuzzy appearance.

(b) "A" classification. Frozen cauliflower that possesses a good character may be given a score of 17 to 20 points. "Good character" means that not less than 80 percent, by weight, of the cauliflower are firm and compact clusters of buds or buttons; and that the remainder of the clusters may be reasonably firm and reasonably compact or may be slightly soft, slightly ricey, or slightly fuzzy.

(c) "B" classification. If the frozen cauliflower possesses a reasonably good character, a score of 14 to 16 points may be given. Frozen cauliflower that falls into this classification shall not be graded above U.S. Grade B or U.S. Extra Standard, regardless of the total score for the product (this is a limiting rule). "Reasonably good character" means that not less than 60 percent, by weight, of the cauliflower are at least reasonably firm and reasonably compact clusters of buds

or buttons; and that the remainder of the clusters may be soft, ricey, or fuzzy but not more than 10 percent, by weight, of the cauliflower may be mushy.

(d) "SStd" classification. Frozen cauliflower that fails to meet the requirements of paragraph (c) of this section may be given a score of 0 to 13 points and shall not be graded above Substandard, regardless of the total score for the product (this is a limiting rule).

## LOT INSPECTION AND CERTIFICATION

### §52.728 Ascertaining the grade of a lot.

The grade of a lot of frozen cauliflower covered by these standards is determined by the procedures set forth in the Regulations Governing Inspection and Certification of Processed Fruits and Vegetables, Processed Products Thereof, and Certain Other Processed Food Products (§§52.1 through 52.87; 22 F.R. 3535).

## SCORE SHEET

§52.729 Score sheet for frozen cauliflower.

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Size and kind of container _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _
Container marks or identification_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _
Label_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _
Net weight (ounces)_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

| Factors | | Score Points | |
|---|---|---|---|
| | | (A) | 34-40 |
| Color _ _ _ _ _ _ _ _ _ _ _ _ _ | 40 | (B) | [1]28-33 |
| | | (S Std) | [1] 0-27 |
| | | (A) | 34-40 |
| Absence of defects_ _ _ _ _ _ | 40 | (B) | [1]28-33 |
| | | (S Std) | [1] 0-27 |
| | | (A) | 17-20 |
| Character _ _ _ _ _ _ _ _ _ _ _ _ | 20 | (B) | [1]14-16 |
| | | (S Std) | [1] 0-13 |
| Total score _ _ _ _ _ _ | 100 | | |

Flavor and odor _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _
Grade _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

[1] Indicates limiting rule.

Recodified in the Federal Register of December 9, 1953, (18 F.R. 7953). Section 52.728 amended May 22, 1957 (22 F.R. 3535).

## GLOSSARY OF TERMS AND ABBREVIATIONS

| | |
|---|---|
| A-RUN | A production run or operation in which the production line was geared to produce Grade A packout. Used only in data analysis as a designator. See Primary Pack. |
| B-RUN | A production run or operation in which the production line was geared to produce Grade B packout. Used only in data analysis as a designator. See Primary Pack. |
| Grade "A" | Processed frozen cauliflower that meets USDA Grade A standards. |
| Grade "B" | Processed frozen cauliflower that meets USDA Grade B standards, but fails to meet Grade A standards. |
| Grader | A company employee charged with the responsibility of grading the raw produce input. |
| Grower | The independent farmer or farming company responsible for the agricultural production of the raw produce. |
| Pack | The total amount of finished frozen vegetable packed in a specific time period, or from a specific input, or from a specific grower. |
| Packer | See Processor. |
| Packout | See Pack. |
| Pieces | The residual of the processing operations. Packable vegetable matter that is too small to meet the USDA standards for size of either grade. Normally not included in the grower's payment. |
| POA | Total pounds packout of Grade A. Used only in data analysis. |
| POB | Total pounds packout of Grade B. Used only in data analysis. |
| POP | Total pounds packout of pieces. Used only in data analysis. |

| | |
|---|---|
| Primary Pack | The grade that the processor has determined to be packed. The production line is geared to processing one specific grade. |
| Processor | The firm that processes quick frozen vegetables. Spiegl Foods, Inc. is a processor. |
| Quick Frozen | The freezing process that includes a rapid freezing evolution in which the temperature of the processed vegetable is rapidly reduced in freezing units and maintained. The vegetable is frozen in its package. |
| Recovery | Usually expressed in percentage of the raw produce input. The amount of vegetable matter recovered and packed during processing. |
| SAMA | Sample weight of Grade A in pounds. Determined by grading. Used only in data analysis. |
| SAMBC | Sample weight of Grade B with color defects. Determined by grading. Used only in data analysis. |
| SAMBM | Sample weight of Grade B with mature pedicels as defects. Determined by grading. Used only in data analysis. |
| SAMD | Sample weight of damaged or rotted vegetable material. Determined by grading. Used only in data analysis. |
| SAMT | Sample weight of trim loss. Determined by grading. Used only in data analysis. |
| SAMWT | The total sample weight. The sum of the five preceding sample categories. Determined prior to actual grading, and double-checked after grading to ensure that total of sample categories equals this figure. |
| TIP | Total input weight in pounds. The input weight associated with a specific case. |
| Trim Loss | The portions of the cauliflower head and plant that are unpackable and therefore unusable in the packing operation. Normally composed of leaves, stalks, dirt and any other foreign matter. |

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